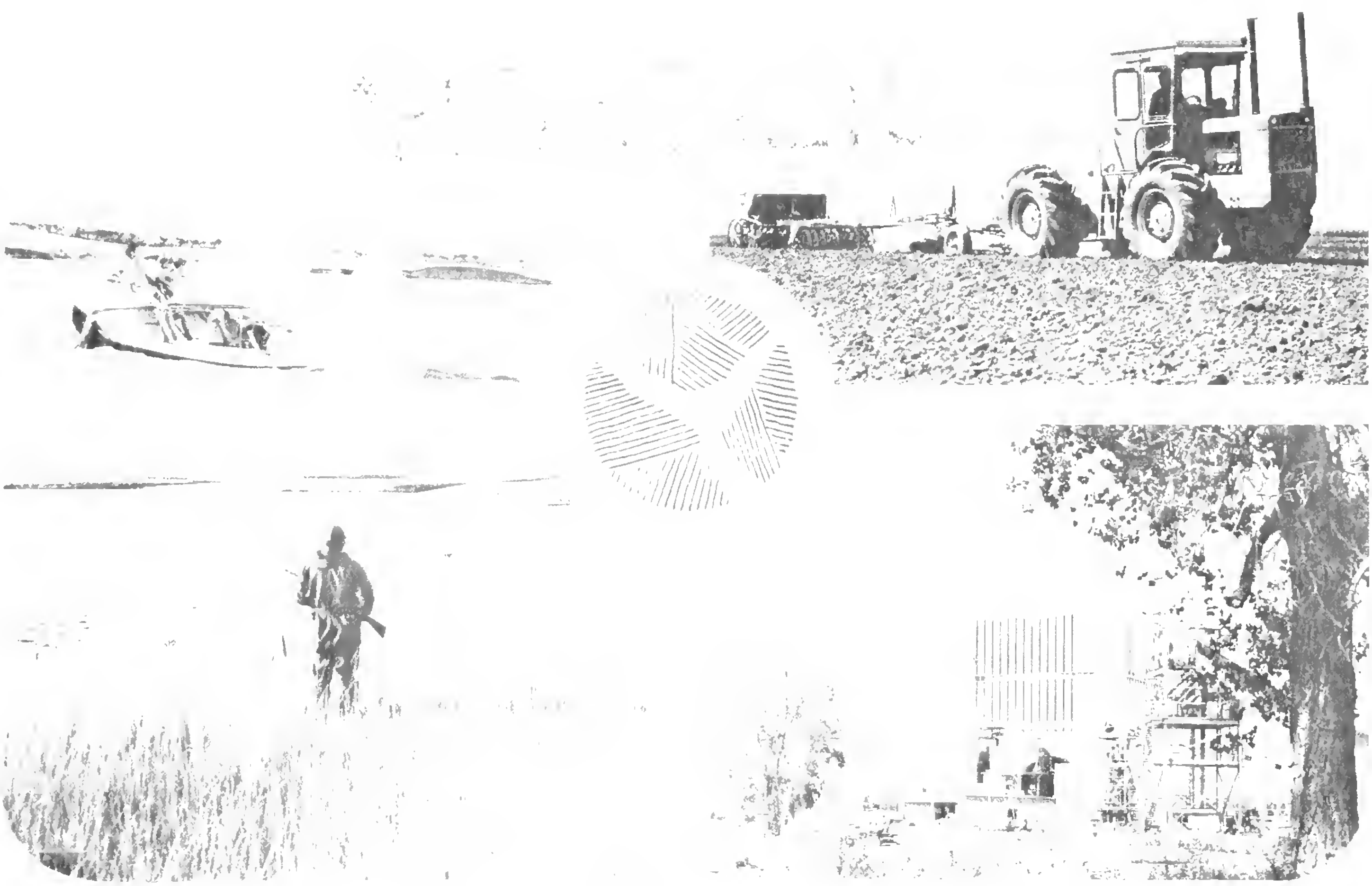
PORT

Volume 6

on the Yellowstone Basin and Adjacent Coal Area LEVEL B STUDY

North Dakota Tributaries



Missouri River Basin Commission
February 1978

mrbc

The Missouri River Basin Commission is the principal agency for the coordination of Federal, State, interstate, local and nongovernmental plans for the development of water and related land resources in the area served by the Missouri River and its tributaries. As an independent regional Commission, it also provides a forum in which States meet with Federal agencies to conduct and coordinate water and related land resources planning. The Commission's chairman is appointed by the President; its vice-chairman is elected from among State members.

MRBC members are Colorado; Iowa; Kansas; Minnesota; Missouri; Montana, Nebraska; North Dakota; South Dakota; Wyoming; Department of Agriculture; Department of the Army; Department of Commerce; Energy Research and Development Administration; Environmental Protection Agency; Federal Power Commission; Department of Health, Education and Welfare; Department of Housing and Urban Development; Department of the Interior; Department of Transporation, Yellowstone River Compact Commission; Big Blue River Compact Administration. Canada is an observer.

YELLOWSTONE BASIN AND ADJACENT COAL AREA

LEVEL B STUDY

NORTH DAKOTA TRIBUTARIES

STUDY TEAM REPORT

NORTH DAKOTA STUDY TEAM

MISSOURI RIVER BASIN COMMISSION

1977

Acknowledgments

The Yellowstone Basin and Adjacent Coal Area Level B study was conducted under the leadership of Robert Madsen, Study Manager (July 1975-February 1976) and Paul Shore, Study Manager (March 1976-December 1977).

The North Dakota portion of the study was conducted under the leadership of:

Don Ohnstad - Assistant Study Manager, North Dakota, MRBC

Lorna Sanders - Secretary to the Assistant Study Manager

State and Federal agency representatives, special interest group representatives and private citizens who participated in the North Dakota study team meetings are gratefully acknowledged for the contributions they made both in the planning and in the writing and review of this report. A total of eight meetings of the North Dakota study team were held. The dates and locations of these meetings and attendance were as follows;

1. April 20, 1976 - Glen Ullin, North Dakota
2. May 18, 1976 - Elgin, North Dakota
3. July 15, 1976 - Killdeer, North Dakota
4. September 29, 1976 - Mandan, North Dakota
5. December 14 & 15, 1976 - Dickinson, North Dakota
6. February 23 & 24, 1977 - Dickinson, North Dakota
7. April 26 & 27, 1977 - Mandan, North Dakota
8. June 1 & 2, 1977 - Dickinson, North Dakota

Name	Representing	Meetings Attended
Albert, W.	Citizen	1
Alt, Bernie	U.S. Forest Service	4
Banks, Bonnie	State Planning Division	1-2-3-4-5-6-7
Beams, Richard L.	Bureau of Indian Affairs	4
Bereuter, Lynn R.	Soil Conservation Service	3
Bieber, Bonnie J.	Citizen	2
Binek, Arnie	Heart River Mutual Aid Corporation	1
Boe, Ed	A.N.G. Coal Gasification	6 8
Brown, Winnifred	Citizen	3
Carey, Rex L.	Bureau of Indian Affairs	5
Carlson, Terry	Soil Conservation Service	1-2- 5-6-7-
Clark, Bruce	Soil Conservation Service	1-2- 4-5-6-7-8
Clark, Dick	Economic Research Service	1- 4-5-6-7-
Cole, Janelle	Dickinson Press	4
Connell, Sidney T.	Billings County W.M.D.	1 5
Crosby, Orlo	U.S. Geological Survey	1-2-3-4-
Cuskelly, Don	Dickinson City Engineer	8
Demke, Keith	State Dept. of Health	1
Dick, Pam	DHS Ecology Club	5
Doering, Red	Agriculture Research Service	4

Name	Representing	Meetings Attended
Duerre, Don	ND Game and Fish Department	5
DuKrey, Allen	Dunn County Planning Office	3
Ekart, Sy	Soil Conservation Service	4-5-6
Ellison, Ike	Natural Resources Coordinator	1
Engel, Austin	State Planning Division	4
Firebur, George B.	Dunn County Commission	3
Firebur, Ione	Citizen	1
Fisk, Allen	Soil Conservation Service	8
Fleet, F. R.	NGPL (Chicago)	4
Fredericks, Daryl	Missouri West Water Systems Coop.	8
Frink, Dale	State Water Commission	1-2-3-4-5-6-7-8
Fuglie, Jim	Mandan News	4
Giese, Archie	Morton County Farmers Union	1 4
Greenshields, Lemore	Dunn County W.M.D.	3
Guenther, John M.	Dunn County Farm Bureau	2-3
Guenther, Milton Mrs.	Citizen	1-2-3- 5
Guimont, Arnie	Indian Lignite Manpower Program	6-7
Halpern, Mike L.	Citizen	1
Hanson, Harold	Citizen	2-3- 8
Harrison, Darrol	U.S. Forest Service	1 4
Hassebrook, Margo	Dickinson Press	5
Hauge, Jeff	State Health Department	2-3-4-5- 7-8
Hill, Daryl	Natural Gas Pipeline Company	2- 4-5- 7-8
Hummel, Raymond	Citizen	3
Hummel, Ruben	United Church of Christ	1-2-3-4-5-6-7-8
Jacobs, Mike	The Onlooker News Magazine	1 4-5
Jewell, Dick	Bureau of Land Management	4
Johnson, Bill	North Dakota REAP	1-2- 4-5- 7-8
Ketterling, Jim	Missouri West Water Systems Coop.	1-2
Kittler, K. K.	NEA REC's	1
Krenz, Gene	State Water Commission	3-4-5-6-7-8
Kuntz, Ton	Lewis and Clark RC&D's	1
Landblom, Rod	Roosevelt-Custer RC&D's	4
Lauch, Emanuel	Bureau of Outdoor Recreation	6
Lefor, Marian	Citizen	5-6-7
Lefor, Richard	Dunn County Farmers Union	1-2-3-4-5-6-7-8
Lotow, Glenda	Natural Gas Pipeline Company of America	7-8
Lovell, John V.	Bureau of Land Management	3
Lunc, Oscar	State Planning Division	1
MacDonald, Helene	Citizen	1- 5-6
Maixner, Richard	Citizen	2- 4-5
Makepeace, George	Dickinson Press	1
Martin, Fred	U.S. Forest Service	1- 3- 5- 7-8
Matdise, Sam	ND Game and Fish Department	5
Melarve, Joel D.	A.N.G. Coal Gasification	7
Mercer, Derwood	Bureau of Reclamation	1-2-3-4-5-6-7-8
Metzger, Charles	State Energy Coordinator	1
Michels, Bill	Bureau of Outdoor Recreation	4- 7-8
Monteith, Dean	Citizen	5-6
Muggli, Ewald	Citizen	1
Myers, Doug	Indian Lignite Manpower Program	3
Nace, Ted	United Presbyterian Church	4-5-6- 8
Nelson, Russell L.	Soil Conservation Service	5

Name	Representing	Meetings Attended
Newton, Evelyn	Dunn County Citizens Committee	2- 4-5-6-7-8
Newton, Layton	Citizen	1- 3- 5-6- 8
Oberlander, Harold	Citizen	5
Parsons, Michael	State Health Department	6
Pense, Ronald	U.S. Bureau of Mines	3-4- 6-7-8
Peterson, Bea	Dickinson Business and Professional Womens Club	1-2- 4-5-6-7-8
Peterson, Carl W.	Citizen	6
Pine, C. H.	Natural Gas Pipeline Company of America	6
Pluck, Casmir	Citizen	5
Poling, Fletcher	Basin Electric Power Coop.	1-2- 4-5-6-7-
Pollestad, Stanley	Citizen	5
Reetz, Gene	Environmental Protection Agency	6-7-8
Renner, Ted	State Board for Vocational Education	1- 3-4-5- 7-
Rivinius, Albert	Grant County W.M.D.	1-2- 6
Rude, Kathy	State Outdoor Recreation Agency	4-5-6-7-8
Sadowsky, Robert W.	Dunn County W.M.D.	3
Schmidt, Gene	Bureau of Land Management	6-7-8
Schmidt, Kristine	DHS Ecology Club	5
Schmidt, Steve	Bismarck Tribune	2 7
Schwandt, Gilbert	Roosevelt-Custer RC&D's	1- 3-
Sheffield, Dorothy	Citizen	5-6
Sickler, Rose	Citizen	1- 4- 6- 8
Silvernagel, Ken	Bureau of Reclamation	2
Smeins, Danny R.	Williston Basin Regional Council	5
Smith, Peter, L.	Soil Conservation Service	5-6
Stefonowicz, Robert	DHS Ecology Club	4-5-6- 8
Stuart, Russ	ND Game and Fish Department	4
Stufft, Wayne	Corps of Engineers	4-5- 8
Swett, Mark	Citizen	1
Thompson, Ken	Soil Conservation Service	5-6
Treuch, Carma	DHS Ecology Club	5
Underwood, Roger	Bureau of Land Management	5
Van Oosting, Madge	Citizen	3
Van Oosting, Wm. R.	Oliver Soil Conservation Service	2-3
Wagner, Robert	NGPL	1- 3- 5-
Wesslund, Paul	Minot Daily News	1
Whitehead, Anton	State Outdoor Recreation Agency	1- 3-4-5-
Whitman, Carl	Three Affiliated Tribes	3
Wilhelm, Arlene	State Water Commission	1-2-3-4-5-6-7-8
Wood, Bob	MDU	1-2-3-4-5- 8
Woodbury, Lorin	Citizen	2
Zacher, Harry	Grant County W.M.D. Chairman	2
Zieman, Delores	Badlands Environmental Association	1-2-3-4-5-6-7-8

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CHAPTER I

INTRODUCTION

Background and Authority

The Missouri River Basin Comprehensive Framework Study, published by the Missouri Basin Inter-Agency Committee in December 1971, stated that the principal planning objectives for the Yellowstone Basin were "to intensify agricultural production and processing of agricultural products, development of industrial processing of coal, and expansion of the recreation and tourist industry."

Shortly after completion of the Framework Study, the national energy crisis placed increasing emphasis upon resource planning in the Study Area. A number of programs and studies (North Central Power Study, Montana-Wyoming Aqueduct Study, Project Independence, Northern Great Plains Resource Program, Eastern Powder River Wyoming Coal Development Environmental Impact Statement, and the Wyoming Framework Water Plan, etc.) were completed that recognized the necessity to accomplish a comprehensive plan for the Yellowstone Study Area at the earliest possible date.

In February 1974, the Missouri River Basin Commission responded to the need for the Yellowstone Study and gave a high priority to its initiation. On April 1, 1974, a request was submitted to the Water Resources Council for funds to develop a Proposal to Study (PTS). At the May 1974 Commission meeting a motion was approved by consensus which directed the MRBC Chairman to appoint a special Action Task Force on the Yellowstone River Basin and Adjacent Coal Areas.

The Action Task Force prepared a course of action which proposed that a Level B type study be undertaken. A PTS was prepared and submitted to the Water Resources Council in July 1974 with a request by the MRBC Chairman for funds to initiate the study in FY 1975.

Funds for initiation of the study were not made available for a FY 1975 start. Thus the proposal was deferred, but with a priority consideration for FY 1976 funding.

In response, the Yellowstone Study was one of two new Level B starts that the President recommended in his FY 1976 budget request. Congressional approval and an appropriation of funds for the study was attained in December 1975 with study program start-up projected for early 1976.

Authority for the study is the Water Resources Planning Act of 1965 (PL 89-80,42 U. S. C. 1962, as amended) and Section 209 amendments to the Federal Water Pollution Control Act of 1972 (PL 92-500, 86 Stat 816). The plan to be prepared is a Level B type, which is regional or river basin in scope and involves a reconnaissance-level evaluation of water and related land resources for the selected area. Level B plans are prepared to resolve complex, long-range problems identified by framework studies and assessments; focus on middle term (15 to 25 years) needs and desires; involve Federal, State, and local interests in plan formulation; and identify alternative plans and recommend action plans or programs to be pursued by individual Federal, State, and local entities.

Purpose of the Report

The overall purpose of the Yellowstone Level B Study is to formulate a comprehensive plan, including alternatives as necessary, for the conservation, development, and management of the water and related land resources of the Yellowstone River Basin and adjacent coal areas to satisfy and accommodate multiple purpose objectives. The study identifies, describes, and recommends those actions or implementation-oriented policies, plans, and programs within each planning area and Study Area that the State Study Team believes are required to fulfill the needs and demands anticipated in the next 10 to 25 years. Certain longer term needs are identified, but emphasis has been placed on near term (1975-1985) and midterm (1985-2000) periods. Because of major commitments involving the development and operation of energy facilities and their effect on the resource base, and the diversities of conflicts and disparities in developmental vs. environmental objectives, major study

efforts have been directed to near-term requirements in order that the Level B plan can serve as a bridge to timely and effective action and implementation programs.

Scope of Study

The Level B Study is comprehensive in coverage of water and related land resources. However, water and related land planning is not starting anew in the study area, as the planning agencies at all levels of government have already produced a baseline of data from studies conducted at various investigative levels. In most respects, plan formulation for the study has involved reconsideration, reanalysis, reformulation, and recombining of program elements into plans which are responsive to changing needs and to evolving state, regional, and national goals. The intent has been to complete an analysis in sufficient detail and depth to provide a reasonable and implementable plan, subject to the findings of Level C studies, for the conservation, development, and management of the area's water and related land resources. National forecasts were used to estimate regional and local development effects on the economy and environment. Alternatives for solving or dealing with problems and meeting planning objectives were evaluated.

The study is of a reconnaissance level. It deals with a broad array of water and land uses, and identifies appropriate agencies to complete feasibility studies (i.e. Level C activities) and implementation actions. An identification of the projects and programs requiring early action provide a guide to subsequent implementation studies.

The time frame used for the analysis depicts 1975 as the base year, with near-term needs evaluated through 1985 and midterm needs through 2000.

Organization of Study

The Missouri River Basin Commission was responsible for the conduct, supervision, and management of the study. Funding of the Federal portion of the study

was through the Water Resources Council directly to the Missouri River Basin Commission. State participation was funded through regular funding channels within each State. Public participation was funded by the organizations or individuals participating, except that mileage to and from meetings was paid by the Commission, to those organizations that requested it.

Study Direction

A Study Manager has been given full authority and responsibility by MRBC to conduct the study, serving under the general supervision and direction of the MRBC Director of Planning and Technical Services. The Study Manager developed work plans, budgets, and schedules for completion of task activities; reviewed and evaluated completed work assignments, reports, and studies for quality control, technical adequacy, integration into overall study efforts, compliance with work plan objectives and compliance with WRC Principles and Standards; and prepared recommendations and reports on results of the study efforts.

The Study Manager also served as Chairman of the Management Group, which advised him on overall management guidance, direction, and control for the study effort.

The Study Manager was assisted directly by three Assistant Study Managers. Each of these serve as coordinator of planning and work activities of the various task activities and study participants in the respective State of assignment. They also maintained continuing liaison with designated representatives of governmental and nongovernmental entities in their respective States for the purpose of delineating and expediting study inputs and outputs.

The Manager and Study Office are located in Billings, Montana, with State offices located in Helena, Montana; Cody, Wyoming; and Bismarck, North Dakota. Figure I-1 graphically displays the study organization.

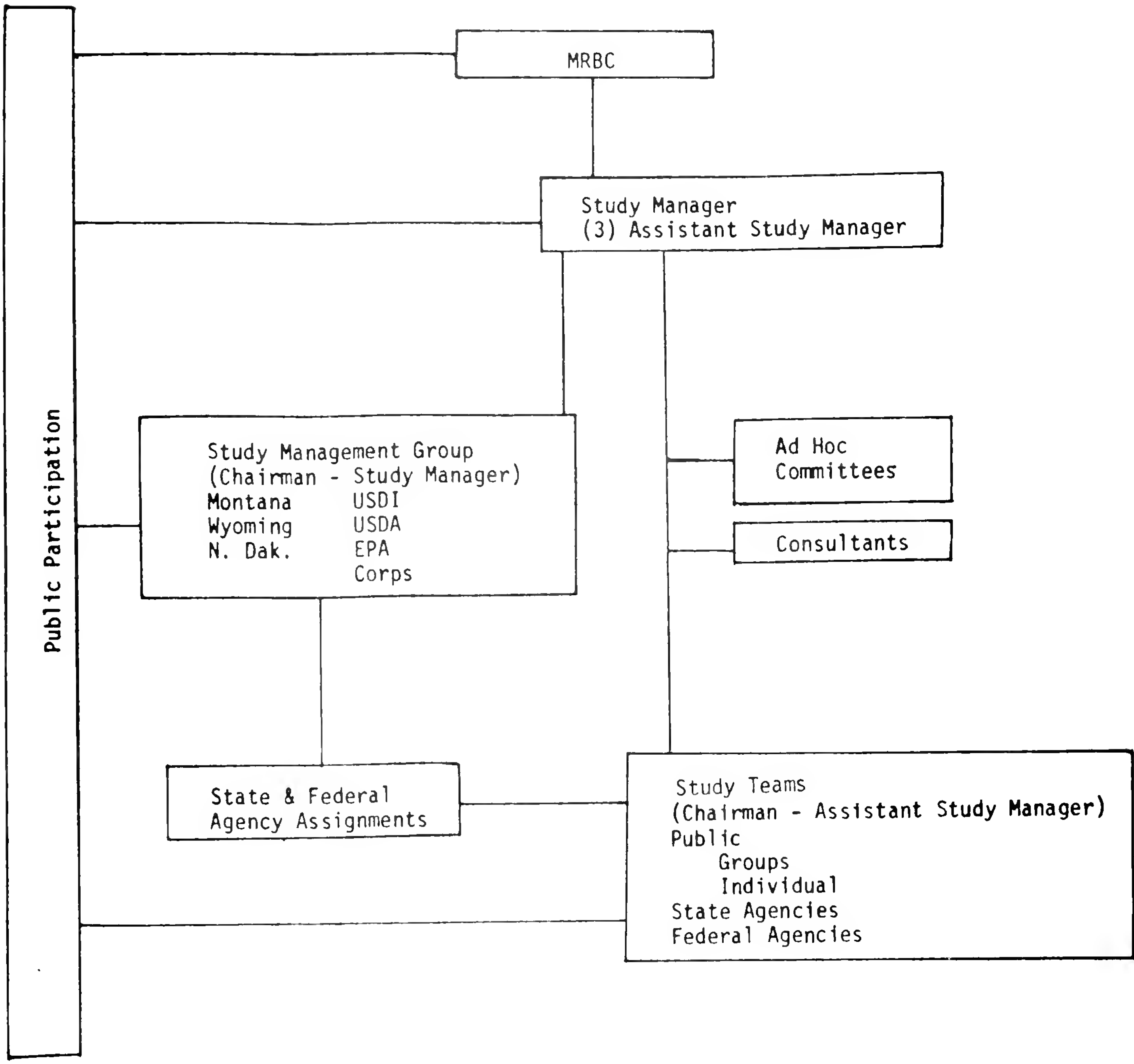
Management Group

The Management Group established for the study was composed of the Study

FIGURE I-1. YELLOWSTONE RIVER BASIN AND ADJACENT COAL AREA

LEVEL B STUDY

ORGANIZATION



Manager and one representative from the Corps of Engineers, Environmental Protection Agency, U.S. Department of Agriculture, Indian tribes, and two representatives of each State and the Department of the Interior. The primary function of the Management Group has been to mold the seven area plans into a plan for the complete study area and provide guidance on management and direction for the study effort. In addition, it provides study performance evaluation critique, and monitoring and control from a resource allocation context. The Group thus provided assistance to the Study Manager in policy formulation, direction, and study problem resolutions.

Ad Hoc Groups

During the early phases of the study certain specific tasks were assigned to ad hoc groups. These groups were composed of agency representatives (Federal, State, local, etc.) with a given expertise and capability to effectively perform the task assignments. The assigned functional areas included: specification of basin demands and needs including agriculture in its broad sense; economic development projections of needs; instream flow needs; and others. Each group prepared a report defining base conditions 1975, projected future requirements (1985 and 2000), the portion of those requirements that will be satisfied through private initiative, and the remaining needs to be met by time frame 1975-85 and 1985-2000. Upon completion of their given assignments, the groups were disbanded.

Study Teams

Plan development, analysis, and associated public participation were handled through Study Teams under the direction of the Assistant Study Manager in each State. Study Teams were composed of members assigned by Federal and State agencies, interested groups, and individuals and industry representatives, with many serving on more than one study team.

The Study Teams have been the most important facet of the study in that they formulated the alternative and recommended plans for each planning area. A typical sequence of events for the Study Team in an individual planning area was:

1. Preparation of a background report.

2. Development of issue papers by an individual agency, group, or citizen involved in the study. Issue papers defined the future of the area without additional Federal or State involvement, the problems and needs this would leave unfulfilled, necessary programs to meet those needs and reconnaissance benefits and costs of suggested programs. The purpose of the first two sections of the issue papers was to provide an objective analysis by each agency to compare with projected needs and future without plan elements as laid out by the ad hoc groups and the staff. This step somewhat parallels the responsibility of the ad hoc groups in the development of projected needs, and the description of the role of the private sector in meeting those needs. The difference would be in scope and degree of narrative. The ad hoc group presentation was primarily technical to cover the entire region with a consistent description of needs and a disaggregation of those needs to the specified planning areas. In contrast, the data provided by each agency and participant was primarily descriptive of the opportunities and problems of the specific planning area. The agency issue papers provided much of the functional description included in this report.

3. The formulation of alternative plans emphasizing National Economic Development (NED), Environmental Quality (EQ), and State-Regional Development (SRD) objectives and the development of a recommended plan, with involvement of the public. Study Team meetings were held in the planning area under study.

State Involvement

This Level B study effort has been heavily oriented to a high degree of State agency participation, both in terms of task performance and policy guidance through service of the Study Management Group. Additionally, each of the respective States assumed a major role through its cost-sharing portion of the total study funding. The degree of State involvement was heightened due to the status of ongoing State programs that are running concurrently with the Level B study effort. As part of its State Water Plan program, the State of Montana is currently working on the Yellowstone Basin. Similarly, the States of Wyoming and North Dakota are moving toward more detailed investigations and evaluations based on their completed Framework Water Plans. Resources expended on these State-oriented efforts provided additional input over and above that of the Level B effort. Similarly, efforts undertaken on the Level B study provide added information for use in the various State plans and programs.

Public Participation

Under the provisions of the Principles and Standards, a continual emphasis on public awareness, involvement, and participation is called for. This is particularly crucial in terms of looking ahead towards effective implementation programs based upon the recommended plans. Considering the large geographic size and diversity of interests in the Study Area, it was deemed inadvisable to structure a formal organizational entity such as a citizens advisory committee, citizens task force, etc. Interest groups within the area, (both developmental and environmental) were already fairly well organized and operationally established. The public was invited to participate directly on the Study Teams, or at their option, to attend and periodically provide data and comments at the study team meetings.

Interstate and Study Area Planning Coordination

Planning coordination for drainage areas crossing State boundaries were coordinated in three ways: (1) the Assistant Study Managers for the respective States maintained constant communication directly and through the Study Manager of the activities in their respective portions of the basin; (2) joint planning meetings between study teams were scheduled when conflicts were evident in planning philosophies or resource availabilities; and (3) the Assistant Study Managers were called upon by the Study Manager to report to the Management Group at appropriate times during the plan formulation process.

The Management Group is responsible for developing the Yellowstone Study Area plans based on the planning area and State plans developed by the State planning teams. The coordination process listed above for interstate planning within the Level B study organization should provide adequate coordination to assure compatability between State plans.

A more difficult coordination problem revolved around the water and related land studies being undertaken by individual, local, State or Federal agencies, when such studies were related to a single function or objective and had a time frame and schedule that did not correspond to those of the Level B study. Attempts were

made to coordinate these activities by the responsible agencies.

Study Area Description

The Yellowstone Study Area encompasses the 52 counties or portions thereof in Montana, Wyoming and North Dakota which are within the hydrologic boundary of the Yellowstone River plus those counties outside the hydrologic boundary, but within the coal rescurce area of eastern Montana and Wyoming and western North Dakota, (see figure I-2). These counties are:

Montana

Big Horn	Gallatin	Park	Sweet Grass
Carbon	Garfield	Powder River	Treasure
Carter	Golden Valley	Prairie	Wibaux
Custer	McCone	Richland	Yellowstone
Dawson	Measher	Rosebud	
Fallon	Musselshell	Stillwater	

Wyoming

Big Horn	Fremont	Niobrara	Teton
Campbell	Hot Springs	Park	Washakie
Converse	Johnson	Sheridan	Weston
Crook	Natrona	Sublette	

North Dakota

Adams	Golden Valley	McLean	Sioux
Billings	Grant	Mercer	Slope
Bowman	Hettinger	Morton	Stark
Dunn	McKenzie	Oliver	

The study area does not include Yellowstone National Park.

For purposes of this study the total area which covers over 123,000 square miles has been subdivided into the seven (7) planning areas delineated on figure I-2.

Montana

Upper Yellowstone
Bighorn - Clarks Fork
Tongue and Powder Rivers
Lower Yellowstone and Adjacent Coal Areas

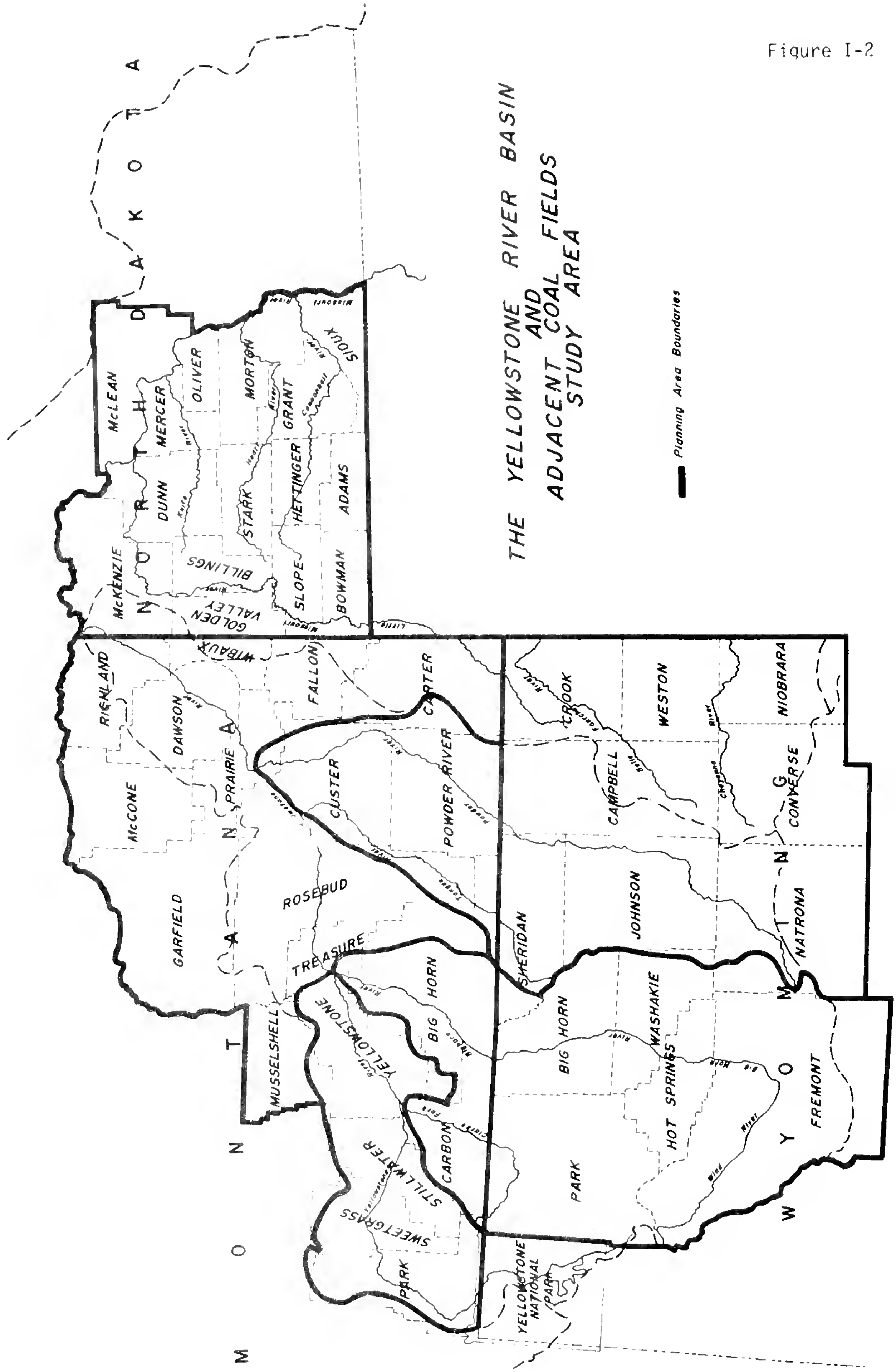
Wyoming

Wind, Bighorn and Clarks Fork
Northeast Wyoming

North Dakota

North Dakota tributaries

Figure I-2



THE YELLOWSTONE RIVER BASIN AND ADJACENT COAL FIELDS STUDY AREA
Planning Area Boundaries
NORTH DAKOTA
MONTANA
WYOMING
McLEAN
MERCER
OLIVER
MORTON
GRANT
SIOUX
DUNN
STARK
HETTINGER
ADAMS
McKENZIE
BILLINGS
SLOPE
BOWMAN
GOLDEN VALLEY
WIBAUX
RICHLAND
DAWSON
PRAIRIE
McCONE
GARFIELD
FALLON
CARTER
CUSTER
POWDER RIVER
ROSEBUD
TREASURE
BIG HORN
MUSSELSHELL
YELLOWSTONE
STILLWATER
CARBON
SWEETGRASS
PARK
YELLOWSTONE NATIONAL PARK
CROOK
WESTON
NIOBRARA
CAMPBELL
CONVERSE
SHERIDAN
JOHNSON
NATRONA
WASHAKIE
HOT SPRINGS
FREMONT

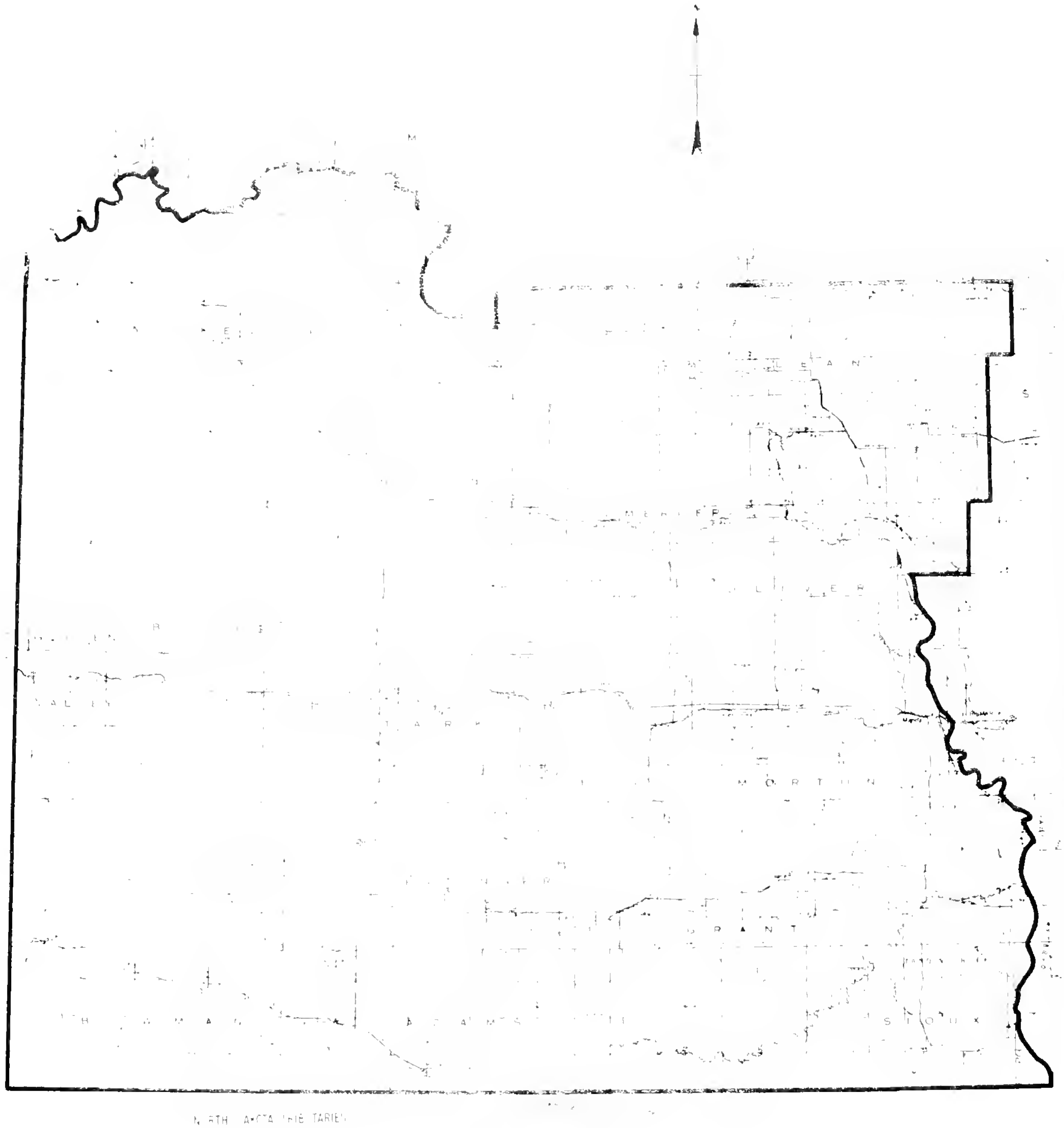
North Dakota Planning Area Description

The North Dakota tributaries portion of the Yellowstone Study area (figure I-3) is bounded on the south by South Dakota, on the west by Montana and on the north and east by the Missouri River with the exception that McLean County lies east of the Missouri River.

This land is rich in history, being a part of the 1803 Louisiana Purchase and home of the aboriginal Indian tribes including the Mandan, Hidatsa, Cheyenne, Cree, Assiniboin, Yanktonai Dakota, Teton Dakota, Chippewa and Arikara. The Lewis and Clark expedition used the Missouri as its roadway to the West. The Marquis de Mores, a French nobleman, came to this land in 1883 to build a packing plant to avoid the expense of shipping live cattle east for slaughter. Another who left his mark was Theodore Roosevelt, who wrote, "we knew toil and hardship and hunger and thirst, and we saw men die violent deaths as they worked among the cattle and horses, but we felt the best of hardy life in our veins and ours was the glory of work and the joy of living." Pioneers to this area were faced with drought, dust storms, prairie fires, grasshoppers and winter blizzards; however, these hardy people were able to adapt and prosper.

The North Dakota planning area covers 15 counties. This 21,831-square-mile area is drained by the Knife, Heart, Cannonball, Grand and Little Missouri Rivers, all major tributaries to the Missouri River. This area, generally referred to as the "Missouri Slope," has a gentle rolling topography with buttes a prominent land form. An outstanding topographic feature of the area is the Badlands. The Badlands, the result of extensive wind and water erosion, occurs along the Little Missouri River in western North Dakota. Three tributary rivers of the Missouri, -- the Knife, Heart and Cannonball -- lie entirely within the North Dakota portion of the study area and are approximately 124, 190 and 204 miles in length, respectively, from their headwaters to their confluence with the Missouri. The North Fork of

Figure I 3   Study Area - North Dakota Tributaries



YELLOWSTONE BASIN AND ADJACENT COAL AREA LEVEL B STUDY
MISSOURI RIVER BASIN COMMISSION

the Grand River begins in central Bowman County flowing southeasterly for about 44 miles then crosses the North Dakota - South Dakota State line. The Little Missouri River, whose headwaters are in northeastern Wyoming, flows through portions of Montana and South Dakota before entering the State in the southwest corner of Bowman County. This river has a channel length of about 220 miles in North Dakota and enters Lake Sakakawea in Dunn County. Only 16 miles of the Yellowstone River channel are within the North Dakota boundary where it has its confluence with the Missouri River near the town of Buford, North Dakota. About 2,800 square miles of land are drained by direct tributaries to the Missouri within the study area west of the Missouri River. This area is characterized by steep bluffs adjacent to the Missouri River and the mainstream reservoirs. McLean County on the east side of the Missouri River, has an area of about 2,327 square miles.

Study Area Objectives

Many of the problems and needs of the Yellowstone Basin were documented in the Missouri River Basin Comprehensive Framework Study Report and others have surfaced since that time. The problems and needs categorized therein were the following:

Municipal and rural domestic water supply
Water quality management and control
Outdoor recreation
Fish and wildlife management
Flood control and management
Agriculture
Industrial water supply
Land and water resources management and administration

Potential conflicts are those between uses which divert water from the streams and rivers and those uses that leave water for instream flow needs. One other conflict, which cuts across all of the above mentioned issues is Federal vs. State water rights as manifested in the Indian and other reserved water rights questions. Many problems arise concerning the dedication and use of Federal, State, and private lands generally and for the mixture of surface/subsurface mineral rights.

To better define the areas of potential problems, the staff identified what appeared to be major or paramount use or user alternatives as:

1) Maintenance and expansion of food and fiber production
2) Maintenance of instream flow levels and adequate quality
3) Impact of energy development programs upon the water resource base supply, and
4) Indian water resource problems

The staff prepared individual issue papers on each of the four topics listed addressing the following: (1) A history of the problem as it relates to the Study Area; (2) Projected future demands or needs; (3) Problem resolution activities being undertaken by Federal, State and local entities to answer the questions and problems; (4) Shortfalls in the various programs activities; and (5) Recommended solutions for resolving the shortfalls. The issue papers recommend specific actions to be taken during the conduct of the Level B Yellowstone Basin Study to aid in problem solutions. These papers also served as background and guideline information for development of task activities and assignments in the Plan of Study.

CHAPTER II

NATURAL RESOURCE BASELINE

Physiography

The study area in North Dakota southwest of the Missouri River, as well as the southwest half of McLean County northeast of the river, is part of the Great Plains province. The northeast half of McLean County is considered to belong to the Central Lowland province.1/

The Great Plains (figure II-1) are rolling to hilly, the result of erosion of generally flat-lying, easily eroded sedimentary rocks. Badlands topography has developed near some streams and rivers, especially along the Little Missouri River. Most of the area is well drained. Only a few natural lakes and ponds are found southwest of the Missouri River in North Dakota although man-made reservoirs are common.

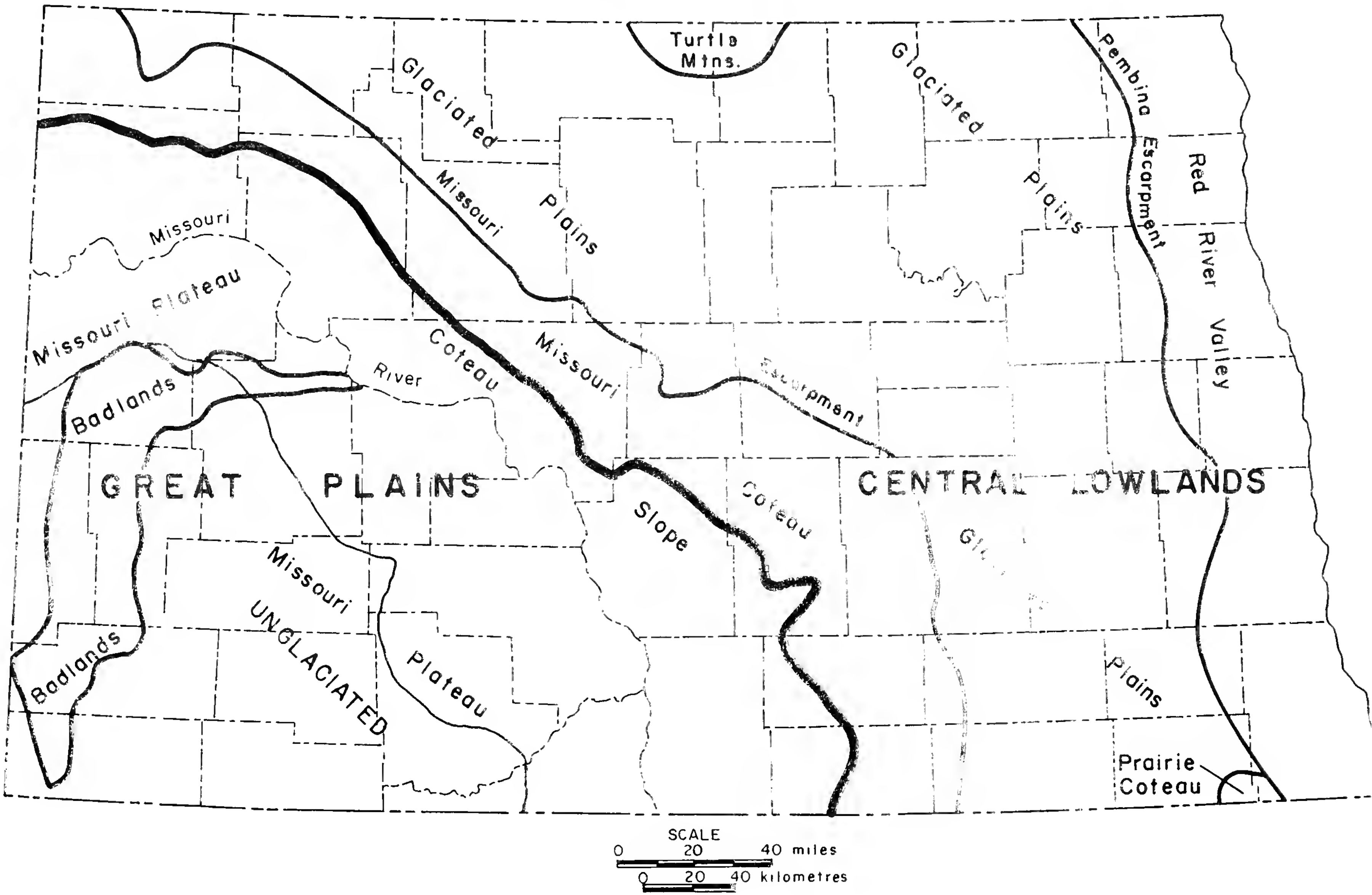
The Great Plains in North Dakota can be subdivided into four main subdivisions: Coteau du Missouri, the Coteau Slope, the Missouri Plateau, and the Little Missouri Badlands. The Coteau du Missouri and the Coteau Slope, which is east of the Missouri River, consist of rolling to hilly plains that have both erosional and glacial dispositional landforms. Approximately 50 to 80 percent of this area is considered to be gently sloping. Local relief ranges from 200 to 500 feet.2/ The Missouri Plateau has largely erosional landforms although scattered patches of glacial sediment do occur in places, especially near the Missouri River. Slopes and local relief are similar to those over the Coteau Slope. The Little Missouri Badlands, a deeply-eroded, hilly area along the Little Missouri River, has gentle slopes over only about 20 to 50 percent of the area. Local relief is commonly over 500 feet.

1/ Physiographers disagree on the boundaries of these provinces. The physiographic provinces actually were established on the basis of plant life, not geology. Thus, the Central Lowland refers to the area that was covered by tall-grass prairie prior to the time the land was settled; the Great Plains were covered by short grass and medium-grass prairie. Some botanists maintain that all of North Dakota is part of the Great Plains.

2/ The term "gently sloping" refers to areas that have slopes of less than 8 percent (4° 35'). Local relief is defined as the maximum difference in elevation within any township-sized area.

Figure II-1

Physiographic Map



The part of McLean County that is included in the Central Lowlands is known as the Missouri Coteau. This area has hummocky topography that resulted when glacial stagnation took place at the end of the latest glaciation, causing collapse of superglacial sediment. Much of the area is poorly drained and numerous small lakes, ponds, and sloughs occur over the Missouri Coteau. Gentle slopes occur over 50 to 80 percent of the Missouri Coteau and local relief ranges from 100 to 300 feet.

Land Resource Areas

The U.S. Department of Agriculture has divided the continental land mass into land resource units. These units consist of large areas, termed Land Resource Regions, that are characterized by similar climate, geologic structure, and land surface form. The Land Resource Regions are in turn divided into Land Resource Areas, which are defined in terms of land use, elevation and topography, climate, water resources, soils, geology, and vegetation. Within the scale of the mapped delineations, Land Resource Areas are homogeneous with regard to a specified range of the above-listed attributes. Such areas may occur as continuous areas or as separate units within the same Land Resource Region.

Within the North Dakota Planning Area are two Land Resource Regions, which are divided into three Land Resource Areas. The Northern Great Plains Spring Wheat Land Resource Region encompasses a large portion of the northern great plains from Montana to Minnesota and from the Canadian border south almost to Nebraska. This region is divided into the Dark Brown Glaciated Plain Land Resource Area, which generally corresponds to the Missouri Coteau physiographic area, and the Rolling Shale Plain Land Resource Area, which is similar in area to the Missouri Plateau physiographic area. The second Land Resource Region, the Western Great Plains Range and Irrigated Region, extends from New Mexico nearly to the Canadian border along the eastern edge of the Rocky Mountain Front. This region just barely touches North Dakota and is divided into only one Land Resource Area in this planning area, the Northern Rolling High Plains Area. This area generally corresponds

to the Badlands physiographic area.

These Land Resource Regions and Areas are another descriptive basis for evaluating the land resources of the planning area, and provide a comparative link between North Dakota and other parts of the Yellowstone drainage. Further details on these regions and areas can be found in the Land Use Ad Hoc Committee Report prepared for this Level B study.

General Geology

Most of the rock and sediment throughout that part of the Study Area southwest of the Missouri River ranges in age from Late Cretaceous through Paleocene, about 130 million years old to 65 million years old. Patches of bedrock that range in age from Eocene to Miocene about 60 million to 15 million years old are also found in places, particularly on some of the buttes. Glacial drift, as much as 75,000 years old, borders the area on the north and east.

Rolling plains, buttes, and badlands have been carved from the surface sediment to form the modern landscape. Erosion has continued intermittently ever since the bedrock formations were deposited. The erosion that shaped western North Dakota was selective in its action. Hard, relatively resistant sandstone and limestone beds have remained as protective caps on buttes and ridges while the softer silt and clay layers have been washed away. Areas covered by grass sod are resistant to erosion. Other materials that effectively resist erosion include layers of reddish scoria, a natural brick that formed when the heat from buried seams of burning coal baked the adjacent sediments; layers of exceptionally hard chert which were probably deposited in ancient swamps as silt that later was silicified; concretions, which form pedestals or log forms as they weather out of the softer surrounding sediment; and, in some places, beds of snail and clam shells and layers of petrified wood.

Even though part of the area southwest of the Missouri River in North Dakota was glaciated at various times during the Pleistocene Epoch, erosion

has largely erased the evidence of these early glacial events except in a narrow area adjacent to the Missouri River, where the glacial deposits are still young and fresh. The small amounts of glacial deposits found throughout most of the glaciated portions of southwest North Dakota are preserved mainly on drainage divides and, to a lesser extent, in deep valleys.

In a few places, gravel deposits are also found on relatively high areas. Most of these deposits are probably either Pliocene or early Pleistocene in age. They were originally deposited in valleys, probably by streams that had their origins in the Rocky Mountains. In areas where such gravel is found on drainage divides, the topography has been inverted since the gravel was deposited; areas that were valleys when the gravels were deposited are now ridges and buttes.

Southwest of the Missouri River in areas that have been glaciated the glacial deposits are generally scanty and consist mainly of scattered boulders and a few areas of thin glacial sediment. Some of these deposits may be early Wisconsinan in age, perhaps 75,000 years old, and it is likely that sufficient time has not elapsed since they were deposited to allow drastic changes in the overall shape of the topography. Relief in most places in the Study Area southwest of the Missouri River is mainly the result of erosion rather than glacial deposition. In contrast to the Missouri Coteau in McLean County, where hills and valleys tend to be close together and rather small, the land southwest of the river is characterized by gently rolling uplands with scattered large hills, buttes, and well-developed valleys.

Subtle differences in the landscape in the Study Area southwest of the Missouri River can be related to the underlying formations. The most apparent differences are the changes in vegetation, which in turn are related in part to the type of soil that has developed. Soils formed on the Hell Creek Formation, for example, tend to be rather poor in quality and they result in an overall "scrubby" appearance of the landscape. By contrast, soils developed on the smooth, rolling land-

scape of the Cannonball and Tongue River Formations in the same area are fertile, a fact that is reflected in the overall good range and crop land.

Large areas have been modified to varying degrees by the action of the wind. Even though recognizable dunes are rare, many of the small irregularities in the surface were shaped largely from wind-blown silt and fine sand and wind-carved grooves in the bedrock surface. This wind-shaped landscape is widespread in many areas, yet it is subtle because modern soil processes have modified it almost beyond recognition.

Even more subtle are the effects of permafrost (permanently frozen ground), which modified the landscape, probably several times, during the Pleistocene Epoch. Ice-wedge fillings are common and permafrost polygons can be seen on aerial photographs of some areas. These polygons are not readily apparent to the ground-based observer.

Pediment surfaces are common throughout the unglaciated part of the State. These eroded surfaces are commonly covered by a few inches to a few feet of locally-derived gravel.

The Badlands of southwestern North Dakota began to form when a glacier diverted the Little Missouri River about 40 miles south of Williston, causing it to flow eastward. Prior to the diversion, not only the Little Missouri River, but also the Yellowstone and Missouri Rivers flowed north into Canada and east to Hudson Bay. As a result of its diversion by the glaciers, the Little Missouri River flowed over a shorter, steeper route than before; and, because of this, the river cut rapidly downward, causing extensive erosion and the carving of the Badlands.

In the southern part of the Little Missouri Badlands near its headwaters, the river has cut down about 80 feet below its preglacial level. In its lower reaches, in the northern part of the Badlands area, the valley floor is about 300 feet below its preglacial level. The eastward-flowing portion of the river, which

has been cut since the glaciers diverted the river, is in a valley that is about 500 feet deep.

The erosion has not been at a constant rate. Since their excavation began, the Little Missouri Badlands have undergone many periods of erosion and deposition. Erosion is most intense during periods of drought because the vegetative cover is insufficient to keep the sediments in place at such times. During the past few hundred years, the badlands have undergone four separate periods of erosion and three periods of deposition. New gullies have been cut to their present depth since about 1936.

That part of the Study Area southwest of the Missouri River in North Dakota is characterized by hundreds of hills and buttes, some of considerable size. Many of the small ones are capped by layers of sandstone, scoria, chert, or other erosion-resistant materials that belong to the same formation that covers the surrounding areas. Some of the larger buttes are capped by younger bedrock formations than those in surrounding areas. Sediment of Eocene Golden Valley Formation caps some of the higher buttes and the Oligocene White River Formation contains resistant beds of limestone that form a caprock on some of the larger southwestern North Dakota buttes such as the Killdeer Mountains, Bullion Butte, and Sentinel Butte.

The northeast half of McLean County, part of the Missouri Coteau has hummocky topography known as dead-ice moraine. This landscape owes its origin to the fact that the glacier had to advance over steep escarpments before it flowed onto the uplands. Elevations rise as much as 600 feet in less than a mile along parts of the Missouri Escarpment, which touches the northeast corner of McLean County and marks the eastern edge of the Missouri Coteau. When the glacier advanced over the Missouri Escarpment, the internal stress resulted in shearing in the ice. Large amounts of rock and sediment beneath the ice were carried into the glacier and to its surface along shear planes in the glacier as it moved onto the uplands. As the glacier melted, about 12,000 years ago, the glacial sediment

tended to accumulate on the top of the ice because the ice at the top of the glacier melted first. The melting sediment cover helped to insulate the underlying ice so that it took several thousand years for it to melt. When the stagnant ice finally did melt, the cover of glacial sediment slumped and slid, forming dead ice moraine, the hilly landscape we see over the Missouri Coteau today.

Scoria

Reddish layers and brick-like masses of baked and fused clay, shale, and sandstone are found in many parts of western North Dakota where seams of lignite have burned, producing heat that baked the adjacent sediments to a form of natural brick that is known locally as scoria.

Range fires may have ignited some lignite beds. Spontaneous combustion, lightning, and the actions of man may have been responsible for other burned lignite seams. Such a large number of lignite seams have burned over such a broad area and under such a variety of situations that it seems likely spontaneous combustion has been responsible for most of the fires. Lignite that contains a high percentage of sulfur is most likely to ignite spontaneously. The ideal situation for such combustion is a finely divided condition of the coal, a slight amount of heat from an outside source, and several feet of overburden to retard heat losses by radiation.

Lignite exposed to air by the removal of the overlying rock due to erosion loses moisture and tends to slack or crumble to fragments. The powdered coal, with a greatly increased surface area, promotes rapid oxidation; in fact, powdered coal absorbs oxygen in quantities at least two to three times its own volume. This absorption of oxygen takes place at ordinary temperatures and, because the process generates heat, it is self-accelerating.

As lignite beds burn, the heat produced bakes and fuses the overlying sediments. As the lignite burns out to an ash that takes up little space, the over-

burden collapses into the burned-out space. By the time the overlying materials collapse, they have been baked to a hard material and they are commonly partially fused as well. As this material slumps it holds together, producing a rock that is as much as 75 percent air space. Oxygen is then admitted through this porous, fractured rock, and combustion gases are carried out so the coal can burn farther back. The intensity of the reddish color of scoria is governed by the mineral composition and grain size of the material that was baked and by the intensity of the temperature reached during the baking process.

Petrified Wood

Petrified wood is found in numerous places in the Study Area. It is especially common in badlands areas where stumps and intact stone tree trunks have weathered from the surrounding sediments. Although most of the area included in the Study Area was probably forested during Paleocene time, the preservation of the wood required that the trees be rapidly buried by sediment so that they escaped decay. This probably happened only in places where streams changed course or flooded their banks depositing sand or silt on the trees.

After a tree was buried, groundwater began to circulate through it. With the help of bacterial action, the water dissolved out the softer cellulose material of the wood. The water also carried dissolved minerals, among them silica (SiO_2), which was deposited in the spaces left in the decaying plant tissue. This went on for a long time, resulting in a gradual replacement of the plant tissue, a molecule of plant tissue being simultaneously replaced by a molecule of silica. In this way, the original cellular structure of the wood was preserved so that, in many cases, the petrified stumps look exactly like old wood stumps except that they are stone. The petrified wood found in southwest North Dakota is mostly light brown or cream colored on the surface; black or dark brown in broken surfaces. Petrified wood seems to be more abundant in the Sentinel Butte Formation than in other formations.

Concretions and Nodules

Concretions are rock structures that have essentially the same composition as the sediments that contain them, but they are generally more resistant than the surrounding sediments. They are the result of the selective deposition from water of cementing materials in the pores of the sediment. Nodules, like concretions, are also harder than the surrounding sediments, but they are of a different composition than the sediments that surround them.

All the geologic formations in western North Dakota contain concretions and nodules of all sizes and shapes. Some concretions are nearly spherical. In some badlands areas, the surface is covered by nodules of siderite (ironstone) which, as they weather out of the surrounding materials, form an erosion-resistant layer. Among the more interesting of the various types of concretions are the "logs," which are elongated sand bodies that have been cemented, in most cases, by calcium carbonate. The log-like concretions formed when mineral-rich groundwater flowed through porous and permeable zones in the subsurface, depositing the minerals in the pores and thereby cementing them to concretions.

Chert

Chert is essentially pure, extremely hard, microcrystalline quartz. The term "chert" is used loosely here. It includes the boulders of material that have been called "pseudoquartzite" or "gannister," chert derived from Paleozoic limestone and dolomite formations in Manitoba and now found in the glacial deposits, and chert found in late Cenozoic gravels (including quartzite, chalcedony, agate, and volcanic rocks) that were carried to western North Dakota by streams flowing from the Rocky Mountains and Black Hills areas.

The type of chert sometimes referred to as pseudoquartzite or gannister is abundant on the surface throughout much of southwestern North Dakota. Its original source is unknown, but it may have formed when silt and very fine sand composed mainly of quartz was blown into swamps where it accumulated and eventually solidified as the swamps dried. This gray, unbedded material has poor

conchoidal fracture and is characterized by the presence of numerous petrified plant stems and stem casts. Much of it may have formed as a result of silicification processes similar to the petrification of wood. It is likely that the chert beds do not represent any single event, but rather a geologic process that was repeated often. Chert of this type is commonly found in the Ludlow, Tongue River, Sentinel Butte, and Golden Valley Formations. Many ridges and buttes in southwestern North Dakota have a cover of chert boulders that help to protect the underlying sediment and minimize erosion. The angular and wind-worn chert boulders are locally abundant, literally paving many of the hilltops in places near the Cannonball River in Hettinger and Grant Counties. They are strewn so thickly in places that it is practically impossible to walk over the areas.

Another variety of chert is the Knife River Flint, which is of particular interest because it was used extensively as a raw material for tools by prehistoric man in the northern Plains and the Midwest. The term "Knife River" is the English translation of an Indian name, which is said to have been given because flint for knives was quarried along the river. The Knife River Flint is found as pebbles, cobbles, and boulders that are as much as 2 feet in diameter. It litters the surface of hill slopes in parts of Dunn and Mercer Counties. It is generally a nonporous, dark brown rock with a conchoidal fracture, making it an excellent material for tools.

Climate[3/]

The Western Dakota Basins lie within the Great Plains Province of the United States. The climate, like that of the Great Plains, is one of relatively little precipitation and frequent droughts, and therefore is classified as dry and semiarid.

Air Masses

Four major masses affect the area. The Continental-Polar air mass originates in the north and is typically dry and cool. The air masses that affect the area most during the growing season are the Maritime-Polar mass that originates in the Pacific Ocean far to the west and north, the moist, warm air mass that originates in the Gulf of Mexico, and the dry, warm air that originates in the center of the United States.

The usually rapid progression of these masses over North Dakota from these different sources results in frequent rapid changes of weather and prevents any current weather regime from becoming monotonous.

Precipitation

The average annual precipitation ranges from less than 14 inches in the west-southwestern portion to 16 inches and over in the east-central area (figure II-4).

In most years, about three-fourths of the precipitation falls during the April to September growing season. Much of the remainder falls as snow, with at least 6 inches of snow being on the ground for 20 to 30 days during the year. Ten to 14 inches of snow correspond to an inch of water in the area.

Temperatures

All parts of the Western Dakota Basins experience a great range of temperature between winter and summer because of the frequent presence of cold continental polar air in the winter and warm continental air in the summer. Average annual temperatures within the area range from 40 degrees F in the northeast to 43 degrees along the southern border. January is the coldest month with average temperatures

3/ Source of figures II-2 through II-11, Climate of North Dakota, Prepared by Ray E. Jensen, Climatologist for North Dakota, National Weather Service, NDSU, Fargo, North Dakota.

FIGURE II-2 ANNUAL MEAN TEMPERATURE
(DEGREES F)

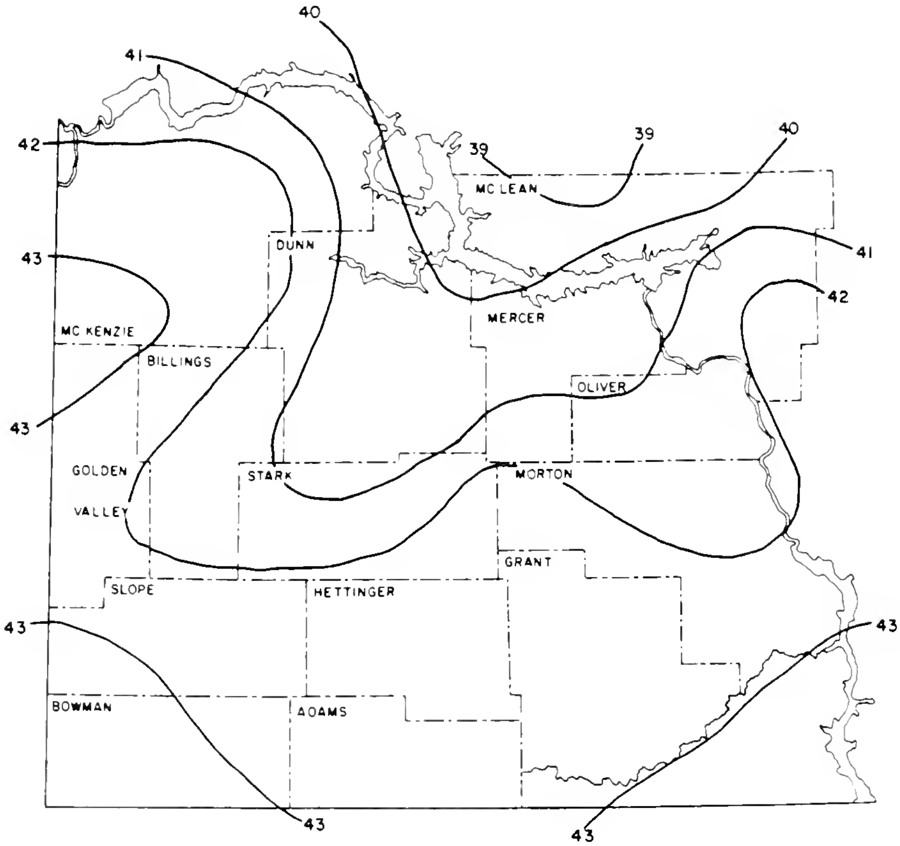


FIGURE II-3 APRIL THROUGH SEPTEMBER
MEAN TEMPERATURE
(DEGREES F)

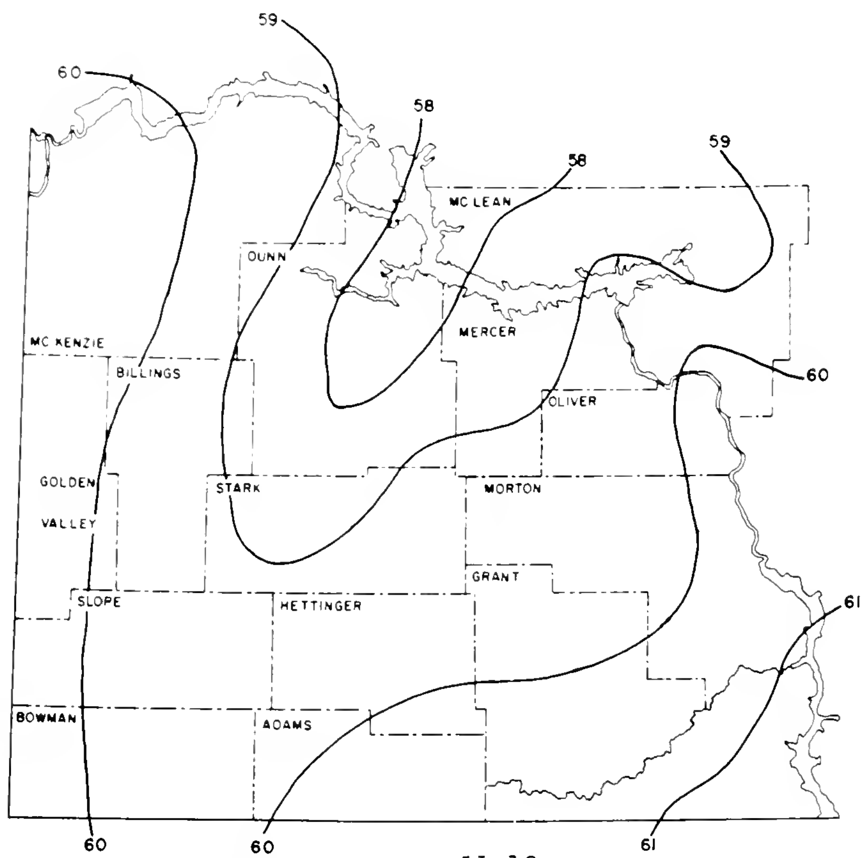


FIGURE II-4 ANNUAL MEAN PRECIPITATION IN INCHES

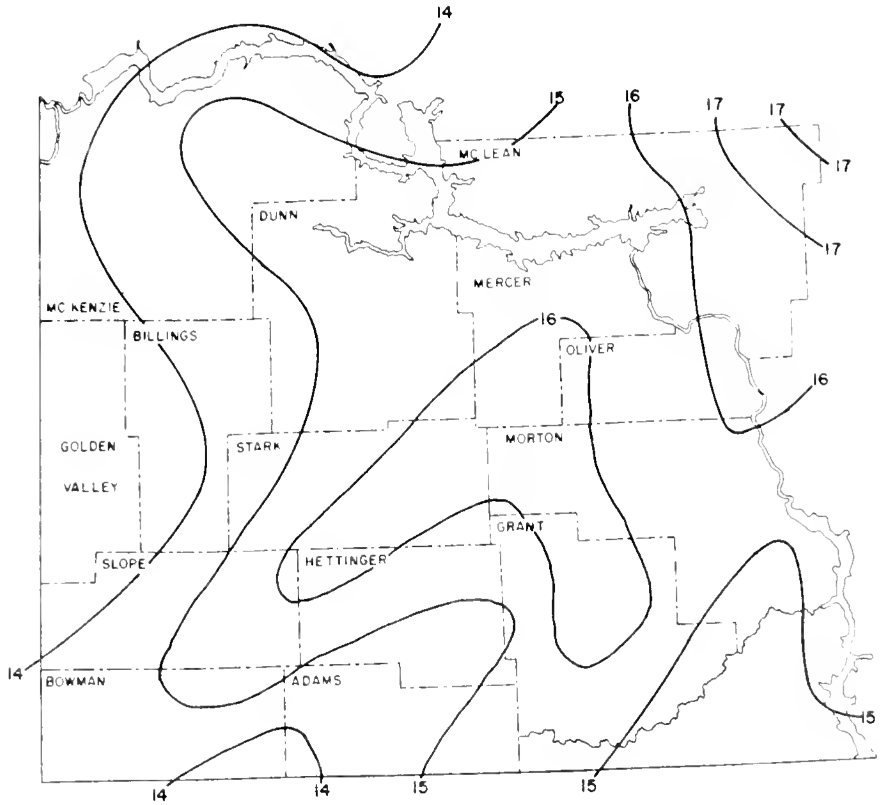
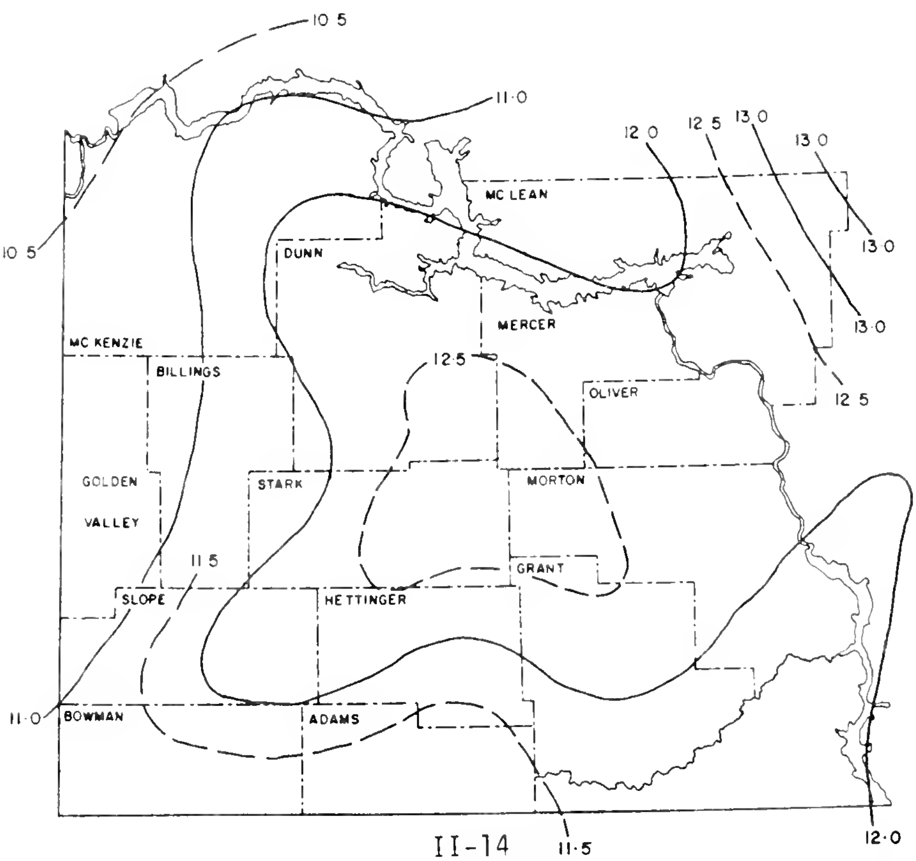


FIGURE II-5 APRIL THROUGH SEPTEMBER MEAN PRECIPITATION IN INCHES



ranging from 8 degrees in the northeast to 17 degrees in the southwest. July is the warmest month with temperatures averaging from 70 degrees in the northeast to 73 degrees in parts of the southern section of the area.

Temperatures of 100 degrees or higher are common in many parts of the area each summer, and temperatures well below zero occur frequently in the winter. Extremes of +118 degrees to -50 degrees have been recorded.

The average length of freeze-free period varies from 120 days in a majority of the area to approximately 130 days in a few areas (figures II-9, 10 and 11).

Wind

Average wind velocities are greatest in late winter and early spring and least in summer. Mean monthly velocities range from slightly under 10 miles per hour in July to above 12 miles per hour in April.

In the study area, wind is most likely to come from the west and northwest, basically as a result of the area's location in the belt of prevailing westerlies. It is not unlikely, however, to receive winds from all points of the compass. There is a constant movement of air over North Dakota at an average velocity of 10 to 11 miles per hour. High winds can last for periods of hours or days during the winter season but are infrequent in summer and then are usually associated with fast-moving thunderstorms.

Relative Humidity

Uncomfortable high relative humidity in the Western Dakota Basins area is seldom encountered. The relative humidity is generally highest during the morning hours and lowest during the afternoon. The following tabulation represents data concerning mean annual and mean monthly relative humidity at Bismarck, North Dakota, at 1 a.m., 7 a.m., 1 p.m., and 7 p.m. respectively:

January	April	July	October	Annual
76 74 67 70	76 79 50 51	79 81 48 48	74 81 51 57	77 79 56 59

FIGURE II-6 AVERAGE MEAN ANNUAL SNOWFALL
FOR PERIOD 1930-31 THROUGH 1959-61
(IN INCHES)

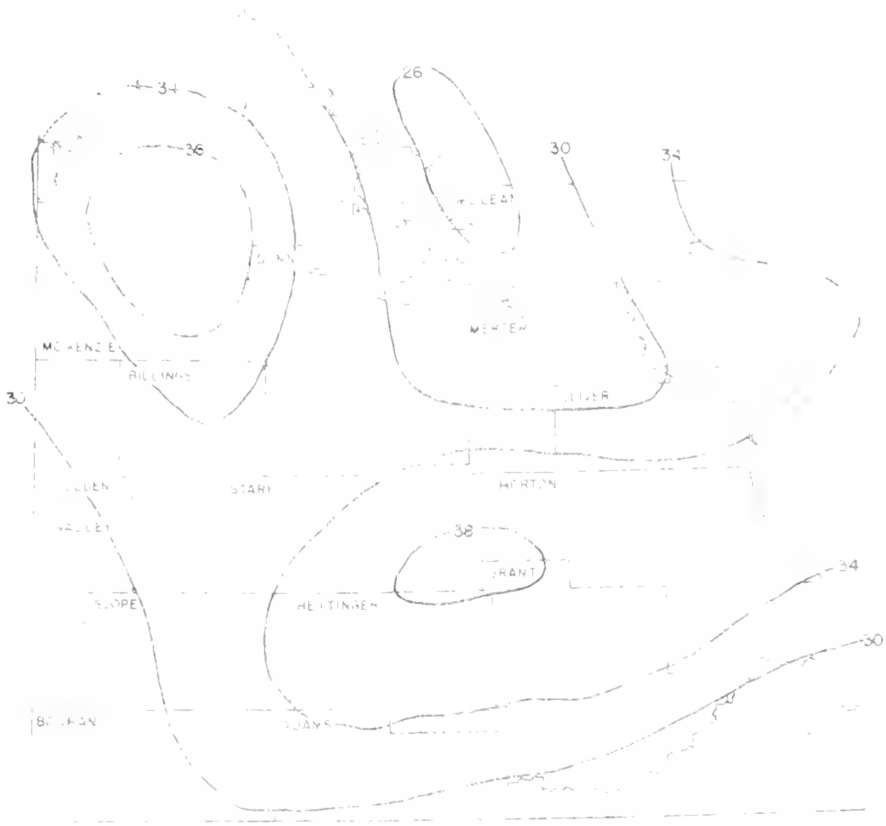


FIGURE II-7 MEAN SEASONAL MAXIMUM SNOW DEPTH
(IN INCHES)

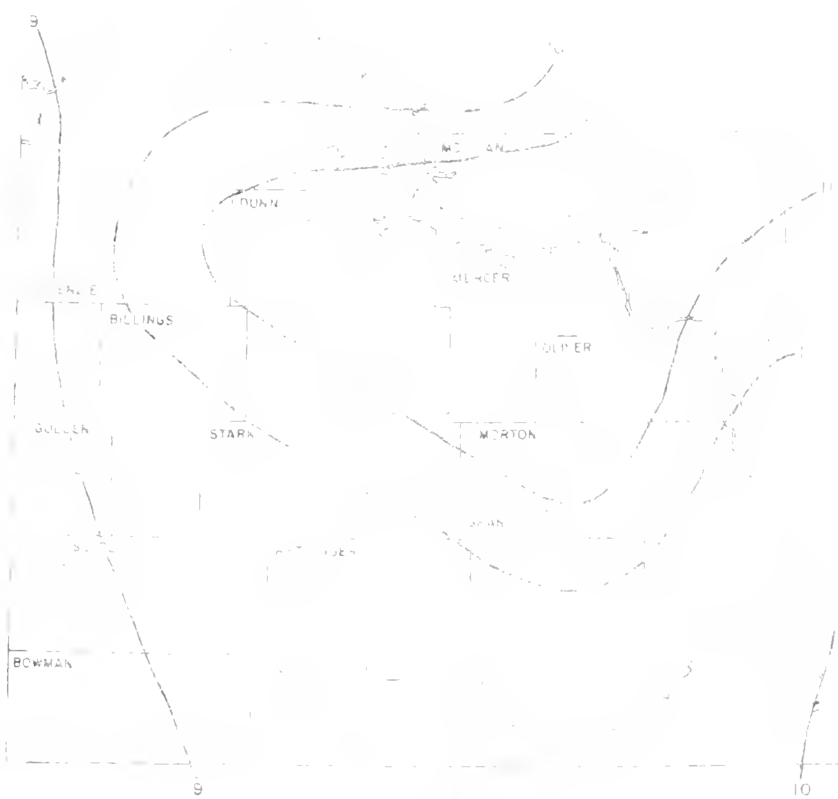
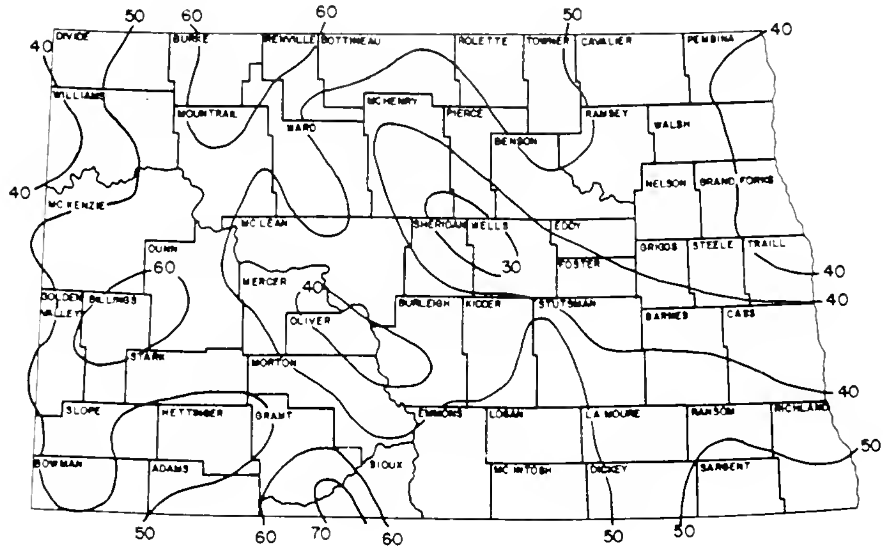


FIGURE II-8 HAIL CLIMATOLOGY



THE MAP SHOWS THE NUMBER OF DAYS WITH HAIL IN A 20-YEAR PERIOD

FIGURE II-9 MEAN LENGTH OF FREEZE-FREE PERIOD
(DAYS)

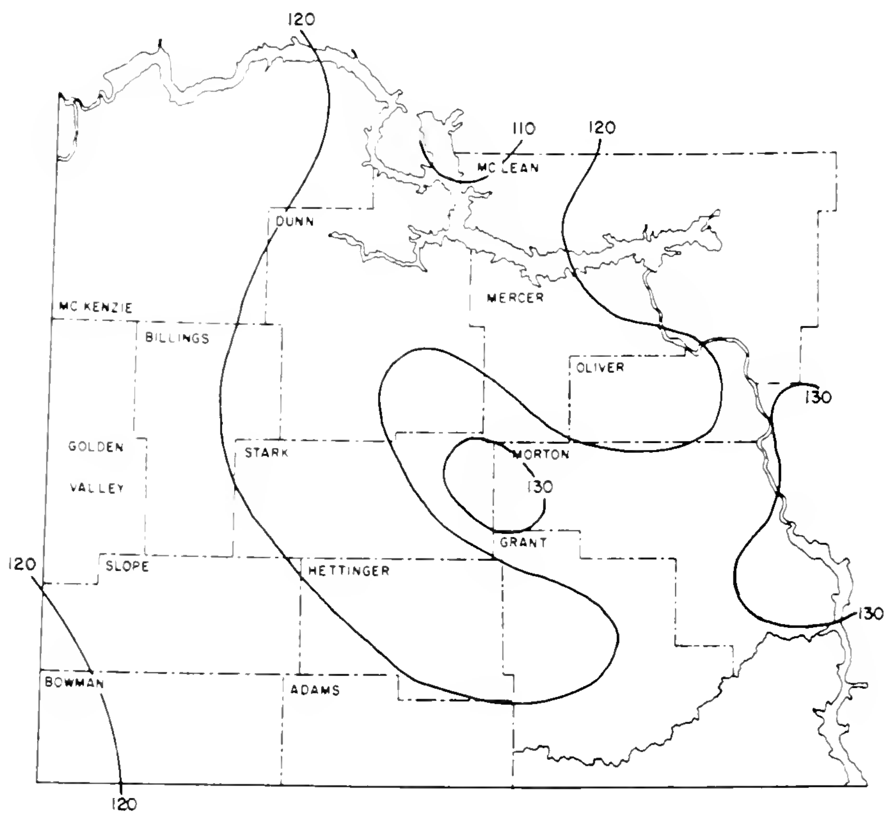


FIGURE II-10 MEAN DATE OF FIRST
32° TEMPERATURE IN AUTUMN

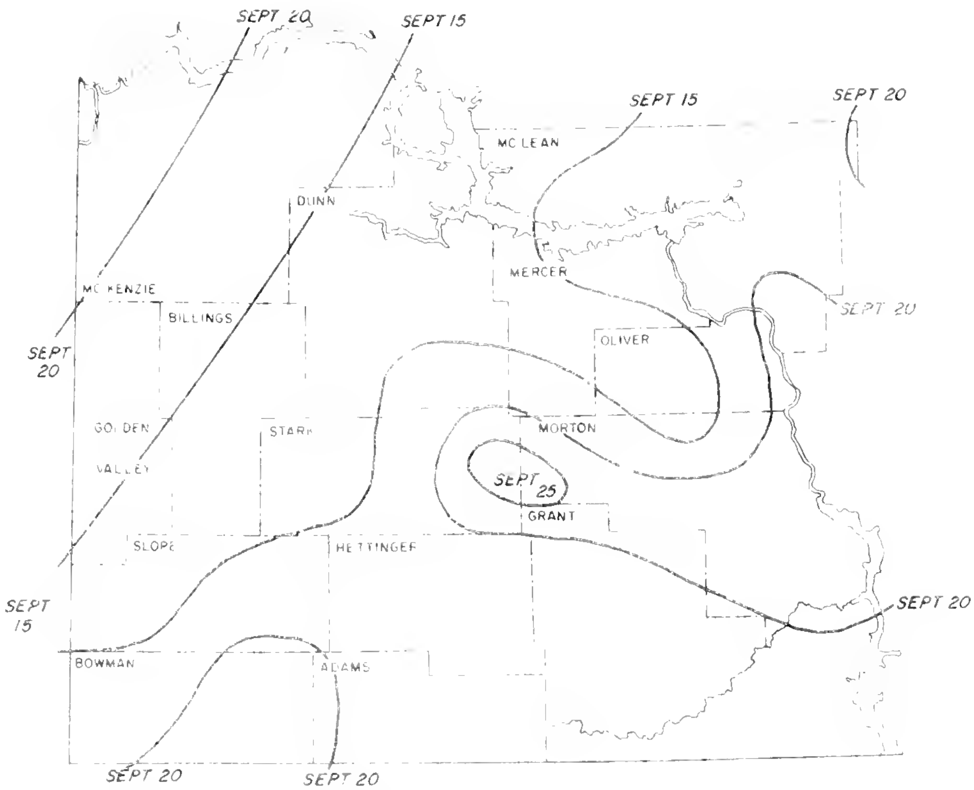
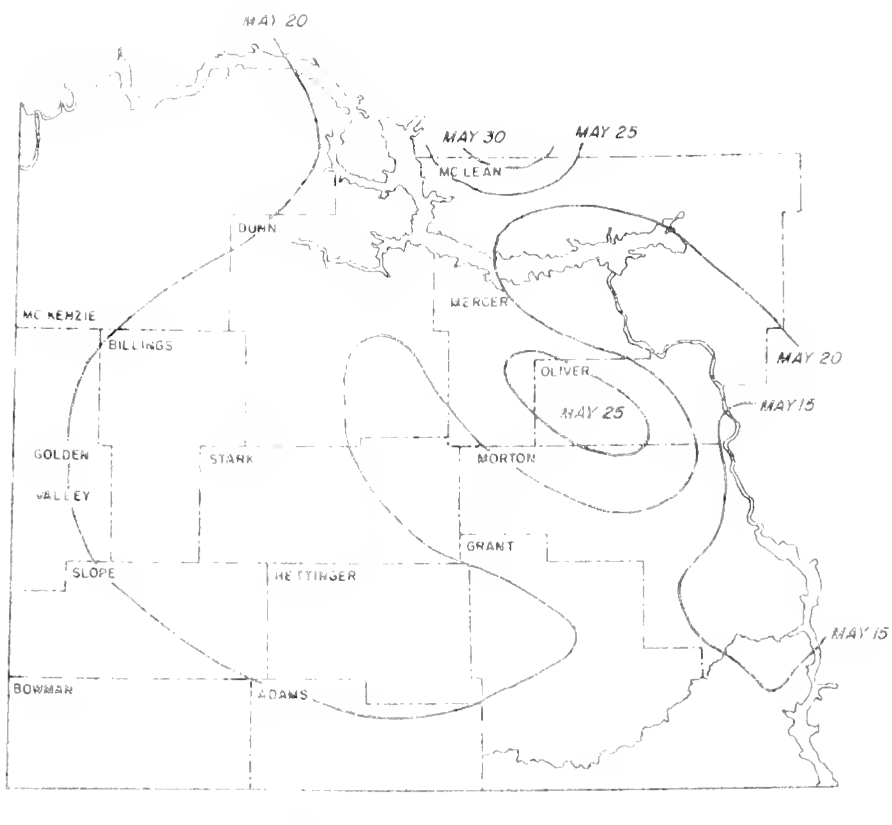


FIGURE II-11 MEAN DATE OF LAST
32° TEMPERATURE IN SPRING



Drought and Wet Spell Occurrences

In an attempt to describe the history of drought and wet spells in southwestern North Dakota, a water balance model that considered climate, vegetation and soil types was developed by the Soils Department at North Dakota State University. The long, severe droughts of the 1930's are clearly shown by this model as well as less severe dry spells of the early 1950's and 60's (figure II-12). The study area has had wetter spells from 1964 through the present.

Severe Storms

Hail poses the greatest hazard of all the severe atmospheric disturbances. Throughout a 20-year period, 40 to 70 days with hail occurrence were reported in the study area (figure II-8). Stark, Hettinger and the northeast corners of McKenzie and Dunn Counties reported more hail damages than other areas in the study area. Most hail occurrences were in June and July.

Tornadoes rarely occur in the area. Three counties reported tornadoes during the period 1940-1970 (31 years). Reports of severe storms,such as tornadoes,are less reliable statistics in unpopulated areas where tornadoes can occur and not be seen by anyone.

Damaging winds that cause damage to crops and buildings occurred most often in June and July of the years between 1940 and 1970. Stark County reported the greatest number of damaging winds.

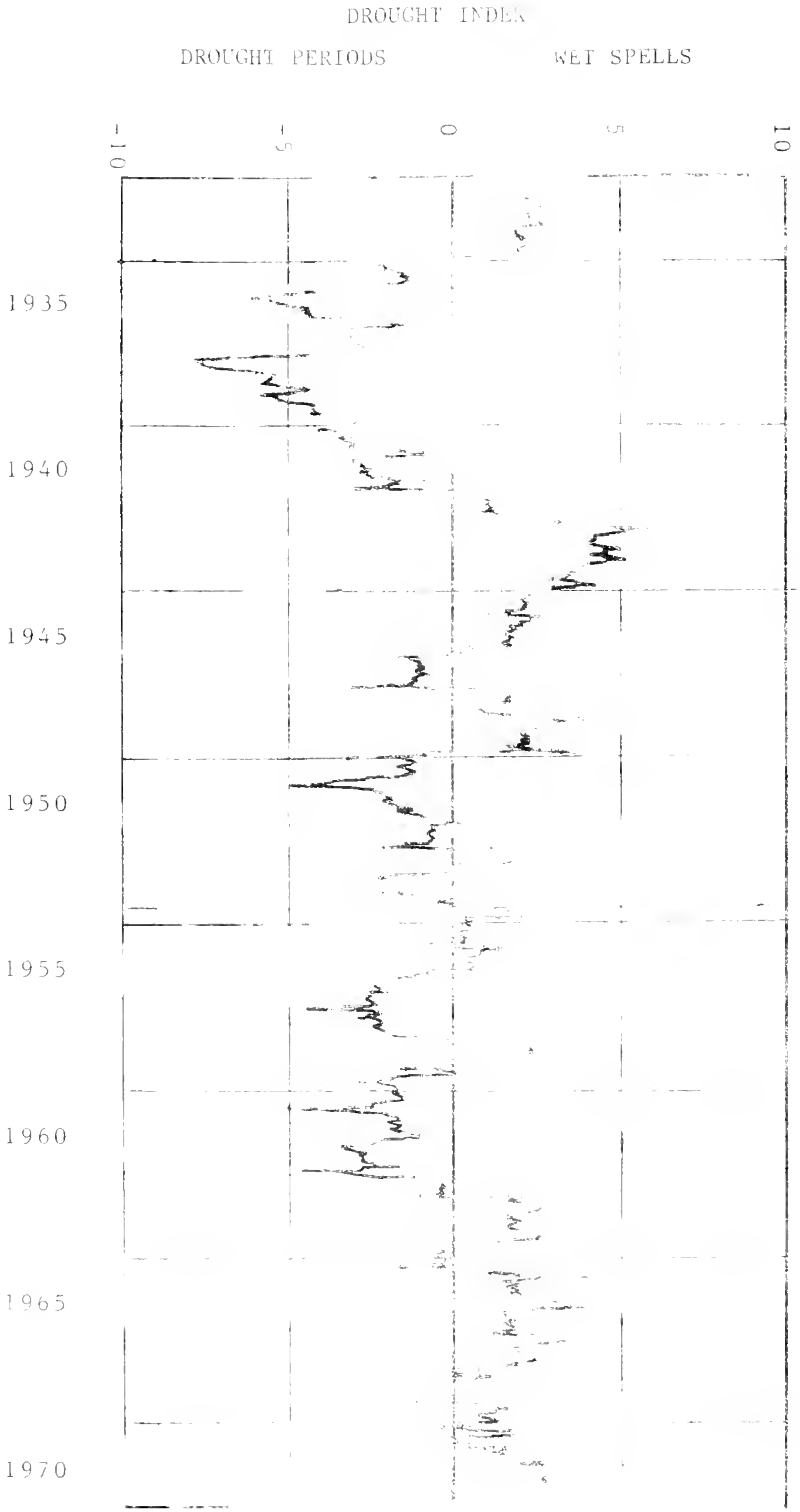


FIGURE II-12 - DROUGHT AND WET SPELLS IN SOUTHWESTERN NORTH DAKOTA FROM 1931 TO 1971

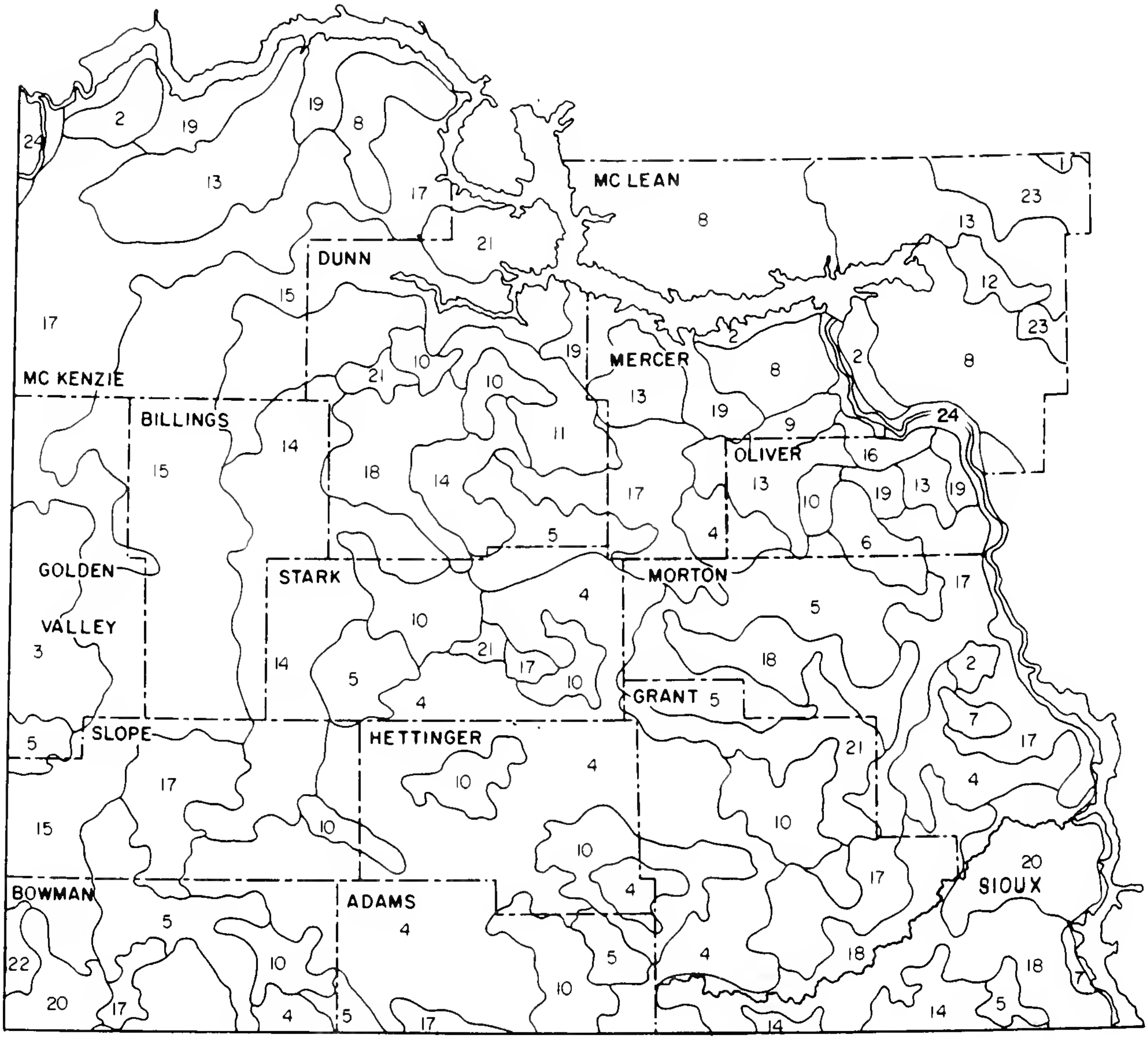
SOILS

The soil associations of the study area are shown on the general soil map (figure II-13). A soil association is a unique landscape unit that has a distinctive pattern of soils, relief, and drainage features. It normally consists of one or more soils of major extent and some soils of minor extent, and it is named for the major soils. The kinds of soils in one association may occur in other soil associations, but in a different pattern.

The general soil map provides a broad perspective of the soils and landscapes in the study area. It provides a basis for comparing the potential of large areas for general kinds of land use. From the map, areas that are generally suitable for certain kinds of farming or other use can be identified. Likewise, areas with soil properties distinctly unfavorable for certain land uses can be located.

For more information on the general soil pattern of the study area the publication, "The Major Soils of North Dakota" by H. W. Omodt, G. A. Johnsgard, D. D. Patterson, and O. P. Olson published by the Department of Soils, Agriculture Experiment Station, North Dakota State University should be consulted. For more detailed information on the soils of the study area, the Soil Survey of Bowman County (1975), Stark County (1968), Oliver County (1975), Morton County (1951), Billings County (1944), and McKenzie County (1942) should be consulted. These publications are available from the Soil Conservation Service or the North Dakota Agricultural Experiment Station.

FIGURE II-13 GENERAL SOILS MAP



Soil Association

Legend for Figure II-13

Soil Associations

Dark Brown Soils of Semi-arid Grasslands

Loam and clay loams

2. Temvik-Williams-Zahl
3. Chama-Morton-Cabba
4. Morton
5. Morton-Rhoades
6. Morton-Williams
7. Savage-Rhoades-Farland
8. Williams
13. Williams-Zahl

Sandy loam and loam

9. Parshall-Lihen
10. Vebar
11. Vebar-Williams

Sandy loam and loam with gravelly substrata

12. Lehr-Sioux

Alkali Soils

14. Rhoades-Morton

Soils on Hilly and Steep Slopes

15. Badlands-Cabba
16. Bainville-Flasher-Temvik
17. Cabba-Morton
18. Cabba-Rhoades
19. Cabba-Rhoades
20. Flasher-Cabba-Rhoades
21. Flasher-Vebar
22. Lismas
23. Zahl-Williams

Soils of Stream Valleys

24. Havre-Banks

Vegetation

The native vegetation that has developed on the lands west of the Missouri River is varied and diverse. The diverse vegetation is characteristic of the local variations in geology, soils and topography. The discussion of vegetation is a general description of the major vegetation types that occur in the region. Vegetation types may be further subdivided into range sites according to range inventory procedures developed by the U.S. Soil Conservation Service. Range sites are basic ecological units used as a practical approach to the study evaluation and management of rangelands.

There are a number of environmental differences throughout a geographical area that exert major influences on the native plant communities. Most important of the natural factors affecting plant composition within the area are soil type, topography, moisture regime, direction of exposure, and presence of excess salts or alkali.

There is much more diversity of vegetation in the rough, broken, North Dakota Badlands than the rolling plains of the Missouri Plateau to the east. According to the Little Missouri Grasslands Study (1974) some 800 species of plants occur in nine western counties of this region. However, many of these species are few in number while a few species are dominant.

In the fifteen county region approximately 50 percent of the total land area is rangeland and only about 1 percent is native woods according to the Conservation Needs Inventory (1970), U.S. Soil Conservation Service. Most of the native woods are confined to the flood plains of the major drainageways and rivers.

Following is a description of the major vegetation types common to the region. Several of these vegetation types were also described in the Little Missouri Grasslands Study (1974). Additional types were added to describe other vegetation types not recognized in the Little Missouri Grasslands Study.

Vegetation Types

Grassland Types

1. Western Wheatgrass - Stipa - Grama type

   A. Distribution: Extensive throughout region
   B. Principal Species: Western Wheatgrass, Needleandthread, Green Needlegrass and Blue Grama
   C. Topography: Nearly level to rolling terrain
   D. Soil Texture: Loam and silt loam

2. Western Wheatgrass - Grama - Sedge type

   A. Distribution: Primarily in western and southern part of region
   B. Principal Species: Western Wheatgrass, Blue Grama, and Upland Sedges
   C. Topography: Nearly level to rolling uplands, river and stream terraces and alluvial fans
   D. Soil Texture: Clay loams and silty clay loams, includes some soils with claypan subsoils (Solonetz)

3. Sandgrass Type

   A. Distribution: Occurs intermittently throughout region
   B. Principal Species: Prairie Sandreed, Needleandthread, and Upland Sedges
   C. Topography: Nearly level to rolling uplands and stream terraces also along river valleys
   D. Soil Texture: Fine sand and sandy loam

4. Little Bluestem Type

   A. Distribution: Primarily in the western and eastern parts of the region
   B. Principal Species: Little Bluestem, Needleandthread, Prairie Sandreed and Upland Sedges
   C. Topography: Undulating to hilly areas, steep slopes and rough broken land
   D. Soil Texture: Varied, sandy loam to silty clay loam, mostly clay loam, silt loam or loam

5. Sagebrush Type

   A. Distribution: Primarily in the western and southern parts of the region
   B. Principal Species: Silver Sagebrush, Big Sagebrush, Western Wheatgrass and Blue Grama
   C. Topography: Stream terraces, valleys and nearly level to moderately sloping uplands
   D. Soil Texture: Varied, clay loam to loamy fine sand, mostly clay loam and silty clay loam, includes some soils with claypan subsoils (Solonetz)

6. Saltgrass - Alkali Meadow Grass Type

   A. Distribution: Primarily in western part of region
   B. Principal Species: Inland Saltgrass, Nuttall Alkaligrass and Western Wheatgrass
   C. Topography: Low stream terraces and depressions, drainage poor
   D. Soil Texture: Ranges from clay to loam

7. Big Bluestem Type

   A. Distribution: Occurs intermittently throughout region
   B. Principal Species: Big Bluestem, Western Wheatgrass and Green Needlegrass
   C. Topography: Occurs on swales, depressions and low stream terraces that receive additional run-in moisture
   D. Soil Texture: Silty Clay to loam

8. Wetland Type

   A. Distribution: Primarily in central and eastern parts of region
   B. Principal Species: Rivergrass, Prairie Cordgrass, Northern Reedgrass, Slough Sedges and other Lowland Sedges
   C. Topography: Occurs on lake basins and depressions in upland plains, drainage poor
   D. Soil Texture: Clay to silt loam

<u>Woody Vegetation Types</u>

9. Green Ash Type

   A. Distribution: Occurs intermittently throughout region and common to the Badlands.
   B. Principal Species: Green Ash, American Elm, and Quaking Aspen
   C. Topography: Occurs in draws, valleys and on north and east facing slopes in the Badlands
   D. Soil Texture: Varied, occurs over a wide range of soils

10. Juniper-Slope Type

   A. Distribution: Confined to the Badlands of North Dakota
   B. Principal Species: Rocky Mountain Juniper, Dwarf Juniper, Creeping Juniper and several Shrub species
   C. Topography: On steeper slopes which possess northwest to northeast exposures, buttes and ravines
   D. Soil Texture: Clay and clay loam

11. Ponderosa Pine Type

   A. Distribution: Confined to the southern part of the Badlands
   B. Principal Species: Ponderosa Pine
   C. Topography: Rolling to hilly
   D. Soil Texture: Shallow soils variable in texture

12. Cottonwood Type

A. Distribution: Along the major drainageways, streams and Missouri River flood plain
B. Principal Species: Cottonwood, Box Elder, Green Ash and American Elm
C. Topography: Level to gently sloping flood plains
D. Soil Texture: Varied, fine sandy loam to silty clay loam

13. Mixed Shrub Type

A. Interspersed throughout the region
B. Principal Species: Buffaloberry, Juneberry, Chokecherry, Wild Plum and Woods Rose
C. Topography: Along streams, valleys, north and eastern-facing slopes
D. Soil Texture: Varied, occurs over a wide range of soils

A number of other plant species are referred to as rare or endangered in North Dakota. Several species are listed in the Little Missouri Grasslands Study and others may occur elsewhere in the region. Some of these species are given as follows:

Ponderosa Pine - Ponderosa Pine groves that are scattered along the Little Missouri River and previously discussed under woody vegetation types of this report. This is the only area of native Ponderosa Pine in North Dakota.

Limber Pine - About 208 acres of Limber Pine are located in western Slope County. No other native stands are found in North Dakota or eastern Montana.

Columnar Juniper - A small stand of Rocky Mountain Juniper of the columnar variety is located near the Burning Coal Vein northwest of Amidon, North Dakota.

Bluebunch Wheatgrass - Bluebunch Wheatgrass is limited to the extreme southwestern corner of the State in northwestern Bowman, Western Slope, southwestern Billings, and southern Golden Valley Counties. This represents the eastern edge of its distributional limits.

Black Cottonwood - Black Cottonwood is found at a place locally known as "Popple Springs" in Billings County. This represents the farthest east extension for this species.

Paper Birch - Paper birch is found in the eastern part of the State and is common to the Turtle Mountains and the Pembina Hills. It is also found in Dunn, Billings, and McKenzie Counties. These western counties represent the most western extension of this species in the State of North Dakota.

Important Farmlands

Maps of the Prime and Additional Farmlands of Statewide Importance in the study area are based on the County General Soil Maps published by the Agricultural Experiment Station, North Dakota State University, and the Soil Survey Staff, Soil Conservation Service, U. S. Department of Agriculture1/. The base soil maps are generalized; therefore, the Prime and Additional Farmlands of Statewide Importance Maps are generalized. More detailed prime farmland maps can be prepared from detailed soil maps. The prime farmlands map drawn from detailed soil maps are more reliable than those drawn from generalized soil maps2/. The generalized soil maps were used because detailed soil maps are not available for all counties within the study area.

The criteria for identification of prime farmlands are entirely related to soil characteristics and other physical criteria. Factors such as nearness to market, transportation facilities, and other economic data are useful in making land use decisions, but they do not affect the intrinsic quality of the land. If land use decisionmakers wish to add information on these factors to the inventory, the basis for land use decisions will be improved.

The term "Prime" means simply the best. The term "Additional Farmlands of Statewide Importance" means next best when compared to "Prime." The criteria for prime farmlands are2/:

1. Adequate moisture supply during the growing season, either from rainfall and stored moisture or from irrigation. Irrigation water quality must be such so as not to cause soil deterioration.

1/ D. D. Patterson, G. A. Johnsgard, M. D. Sweeney, and H. W. Omodt; Bulletin No. 473, Soil Survey Report, County General Soil Maps, North Dakota, Department of Soils, Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota 58102, July 1968.

2/ William M. Johnson; Classification and Mapping of Prime and Unique Farmlands; Prospectives on Prime Farmlands, U. S. Department of Agriculture, July 1975.

2. Mean annual soil temperature greater than 0 degrees C, and mean summer soil temperature greater than 8 degrees C.

3. Lack excessive moisture, the soil should not be flooded more often than once in two years, and the water table maintained at a depth below the rooting zone of the growing crop.

4. Soil must lack excessive soil acidity, alkalinity, and salinity.

5. Permeability of at least .15 cm/hour in the upper 50 cm. of soil.

6. Surface soil must not be so gravelly, cobbly, or stony as to interfere seriously with power machinery.

7. The soil must be deep enough to permit adequate soil moisture storage and unhampered root development.

8. Soil must not be excessively erodible. More detailed criteria are contained in U.S.D.A. Soil Conservation Service Memorandum4/.

The criteria for additional farmlands of statewide importance are the same as those for prime, except that the supply of moisture during the growing season is less but sufficient to produce the commonly grown crops in five out of ten years, and the soil may have an erosion hazard that can be controlled by intensive residue management plus supporting structural practices. More detailed information are contained in U.S.D.A. Soil Conservation Service Memorandum5/.

It is important to emphasize that prime and additional farmlands are some of North Dakota's most important resources. These exceptional lands can be farmed continuously without degrading the environment. They will produce the most food, feed and forage with the least amount of energy used. They respond well to fertilizer and other chemical applications with limited loss of residues by leaching or erosion. These lands have the highest percentage of soils that can be minimum tilled. They

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4/ U.S.D.A., Soil Conservation Service, Land Inventory and Monitoring Memorandum 3, Prime and Unique Farmlands; Washington, D.C., October 15, 1975.

5/ U.S.D.A., Soil Conservation Service, Land Inventory and Monitoring Memorandum 1, Prime and Unique Farmlands; Bismarck, North Dakota, April 16, 1976.

are the most responsive to management and require the least investment for maintaining productivity.

The decision to protect or use prime farmlands and additional farmlands of statewide importance is the responsibility of State and local decisionmakers. The maps (figures II-14 through II-29) in this report can be an important tool for those who deal with the question of prime land and who make decisions on allocating resources.

GENERALIZED Prime and Additional Farmlands of Statewide Importance

60 - 85 Percent Prime and Additional Farmlands of Statewide Importance

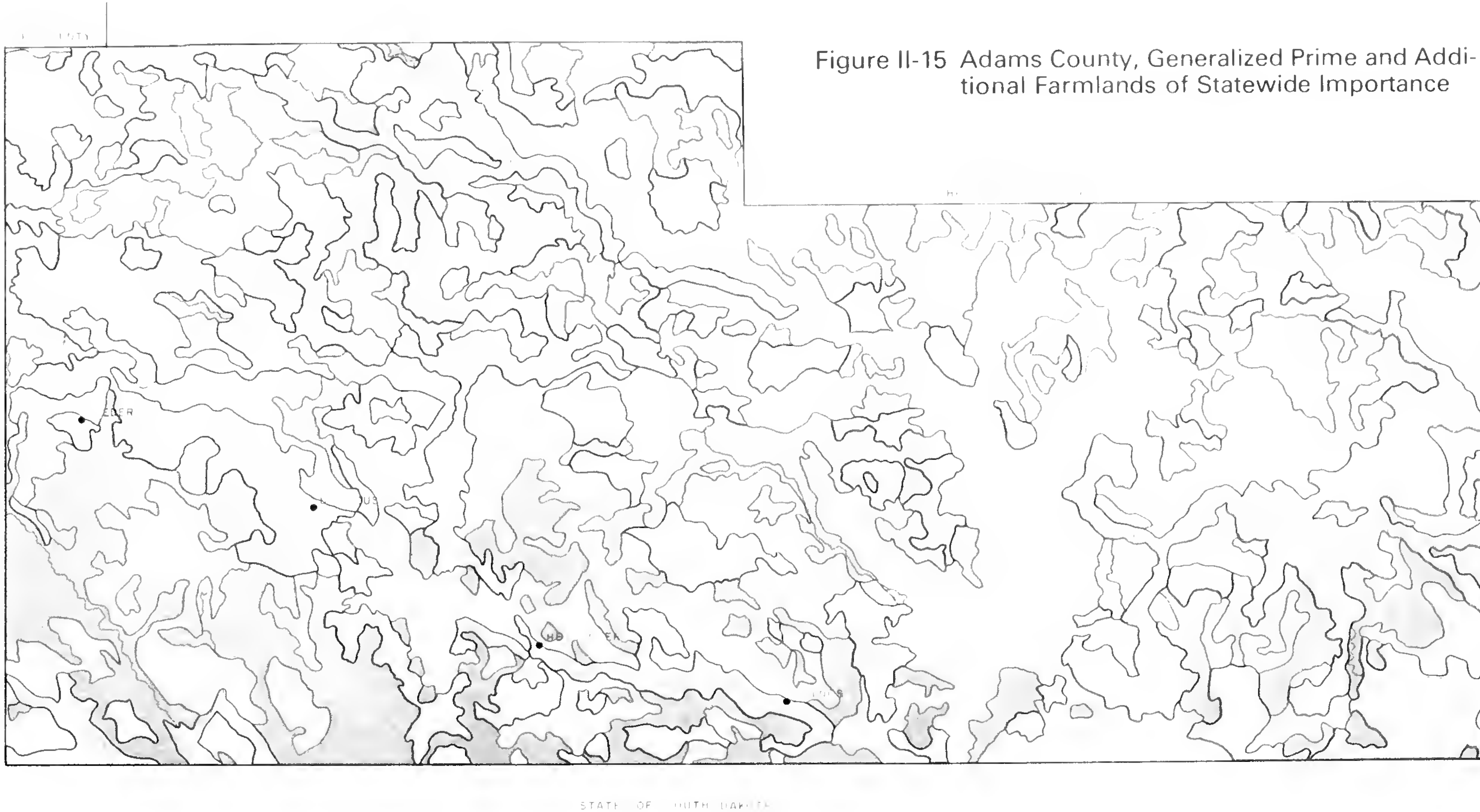
40 - 60 Percent Prime and Additional Farmlands of Statewide Importance

0 - 40 Percent Prime and Additional Farmlands of Statewide Importance

Soil Conservation Service - 1977

Figure II-14 Legend, Generalized Prime and Additional Farmlands of Statewide Importance II-31

Figure II-15 Adams County, Generalized Prime and Additional Farmlands of Statewide Importance



ADAMS COUNTY

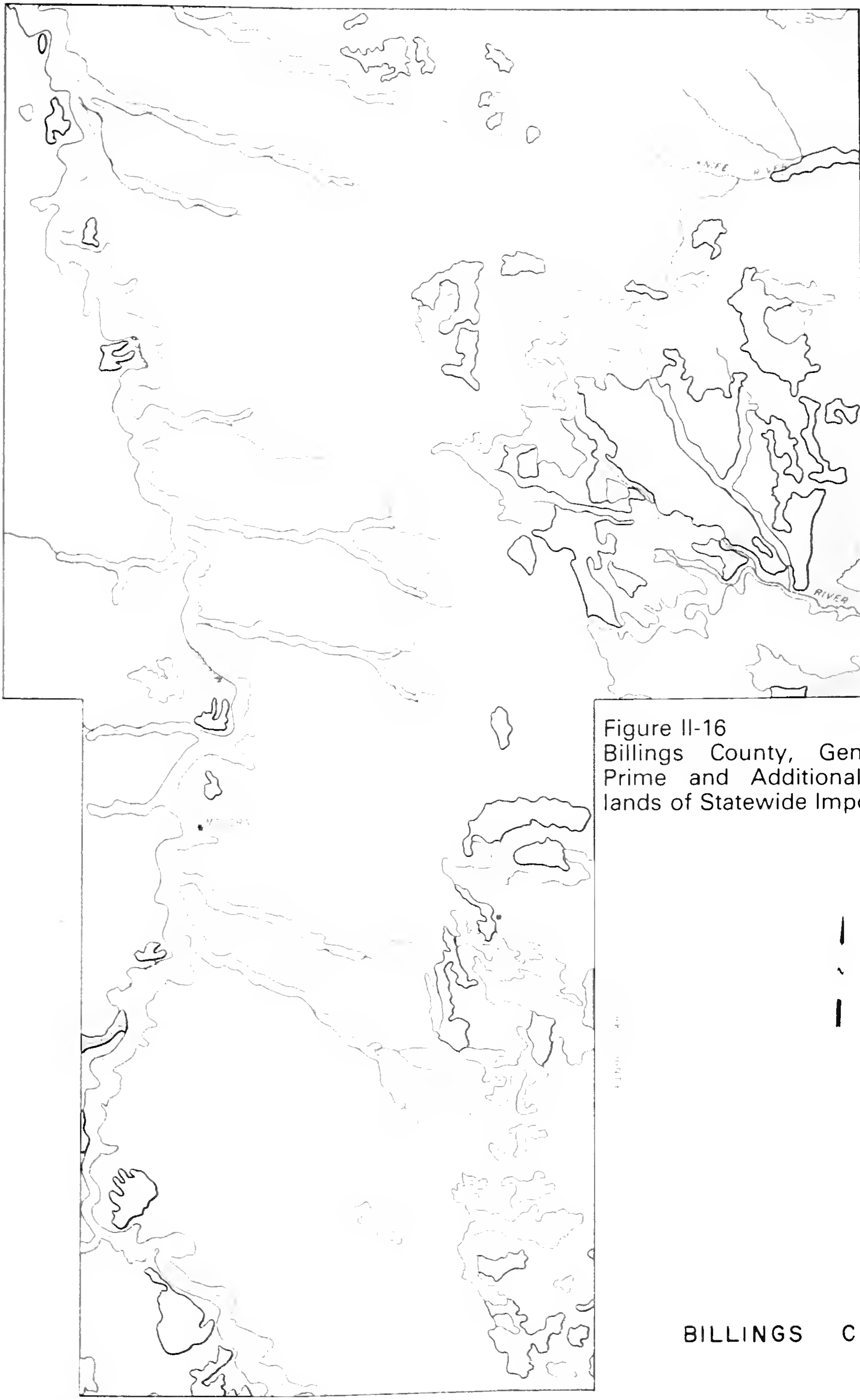


Figure II-16
Billings County, Generalized Prime and Additional Farmlands of Statewide Importance

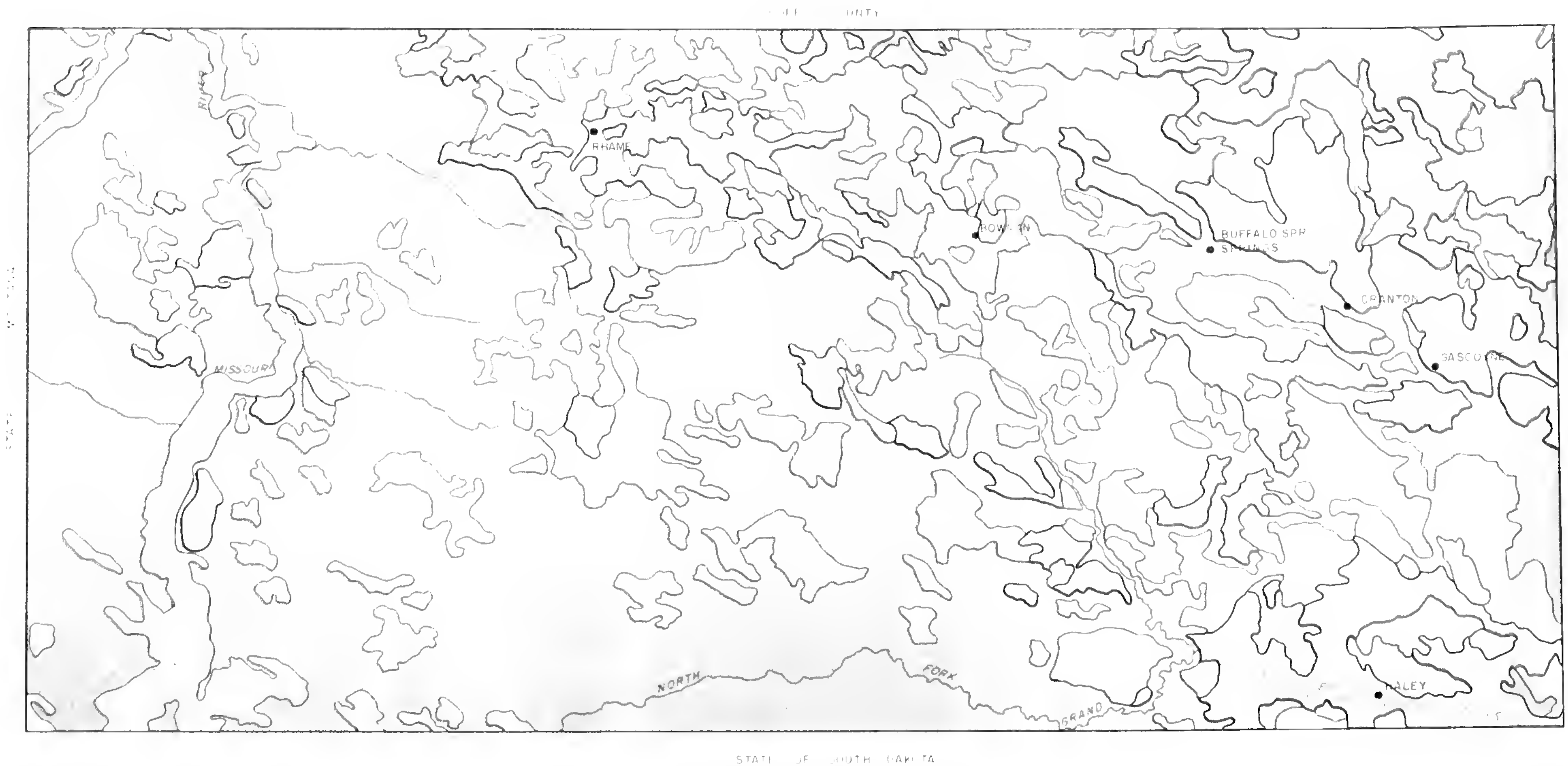


Figure II-17 Bowman County, Generalized Prime and Additional Farmlands of Statewide Importance

BOWMAN COUNTY

Figure II-18 Dunn County, Generalized Prime and Additional Farmlands of Statewide Importance

DUNN COUNTY

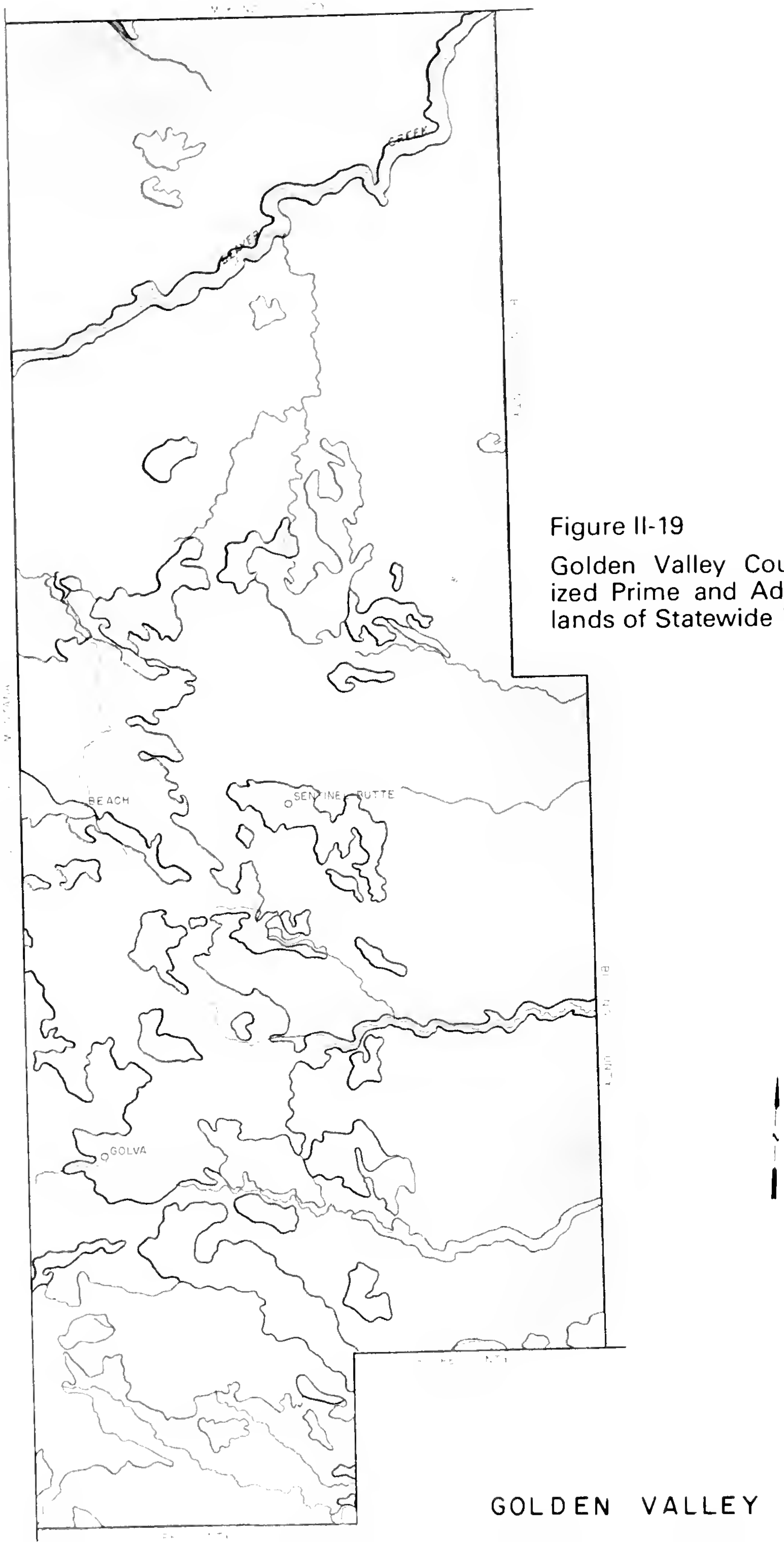
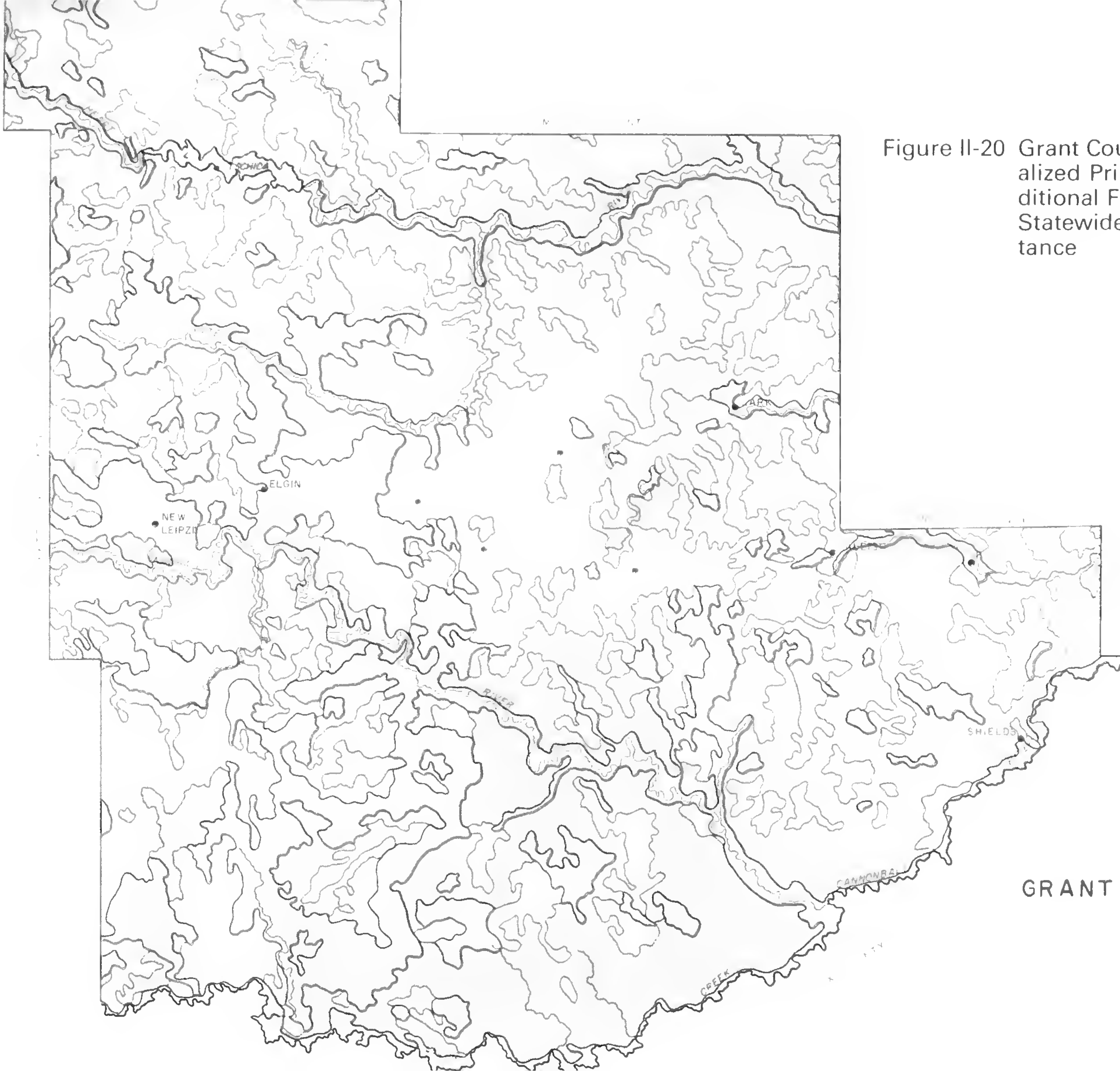


Figure II-19

Golden Valley County, Generalized Prime and Additional Farmlands of Statewide Importance

Figure II-20 Grant County, Generalized Prime and Additional Farmlands of Statewide Importance



GRANT COUNTY

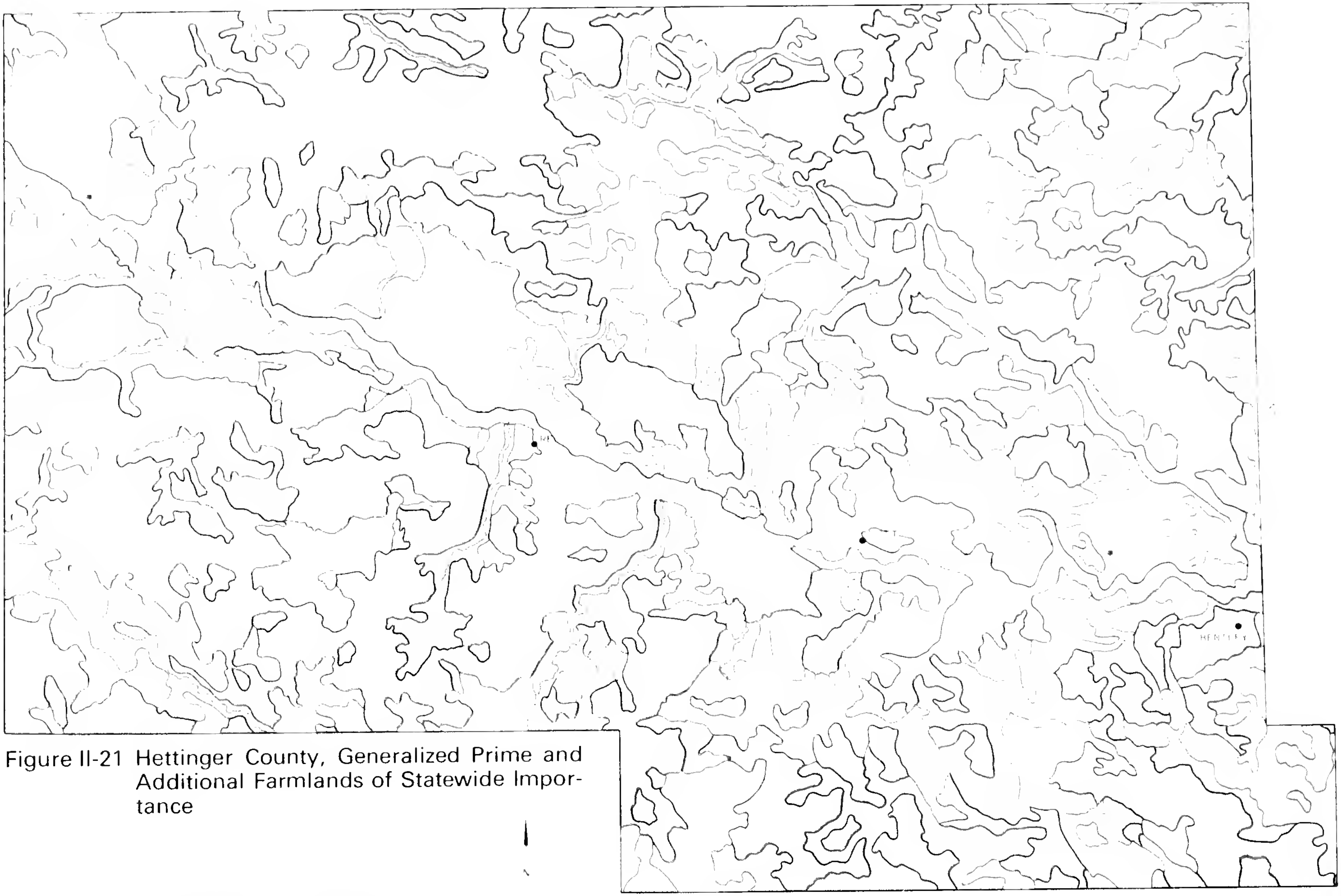


Figure II-21 Hettinger County, Generalized Prime and Additional Farmlands of Statewide Importance

HETTINGER COUNTY

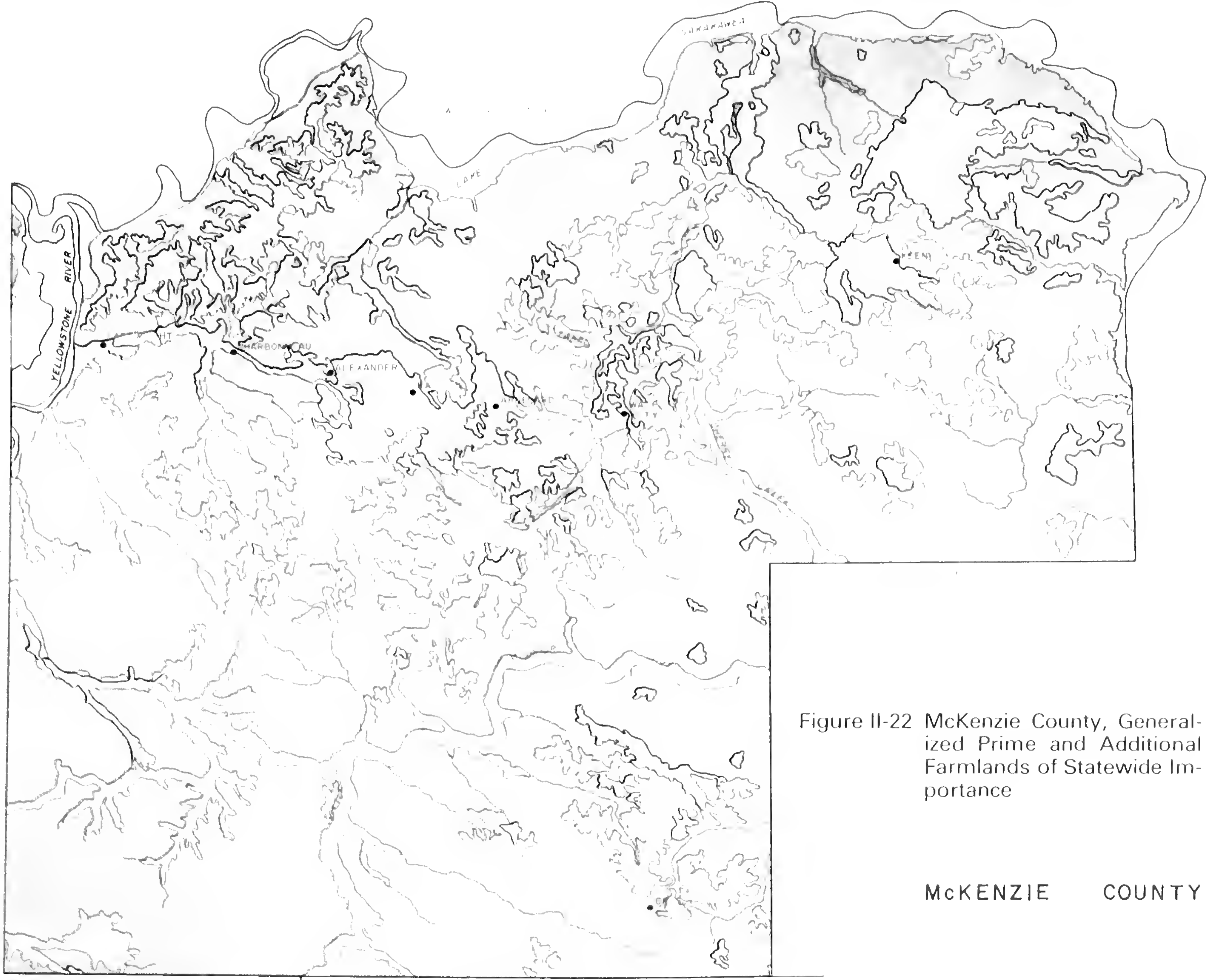


Figure II-22 McKenzie County, Generalized Prime and Additional Farmlands of Statewide Importance

MCKENZIE COUNTY

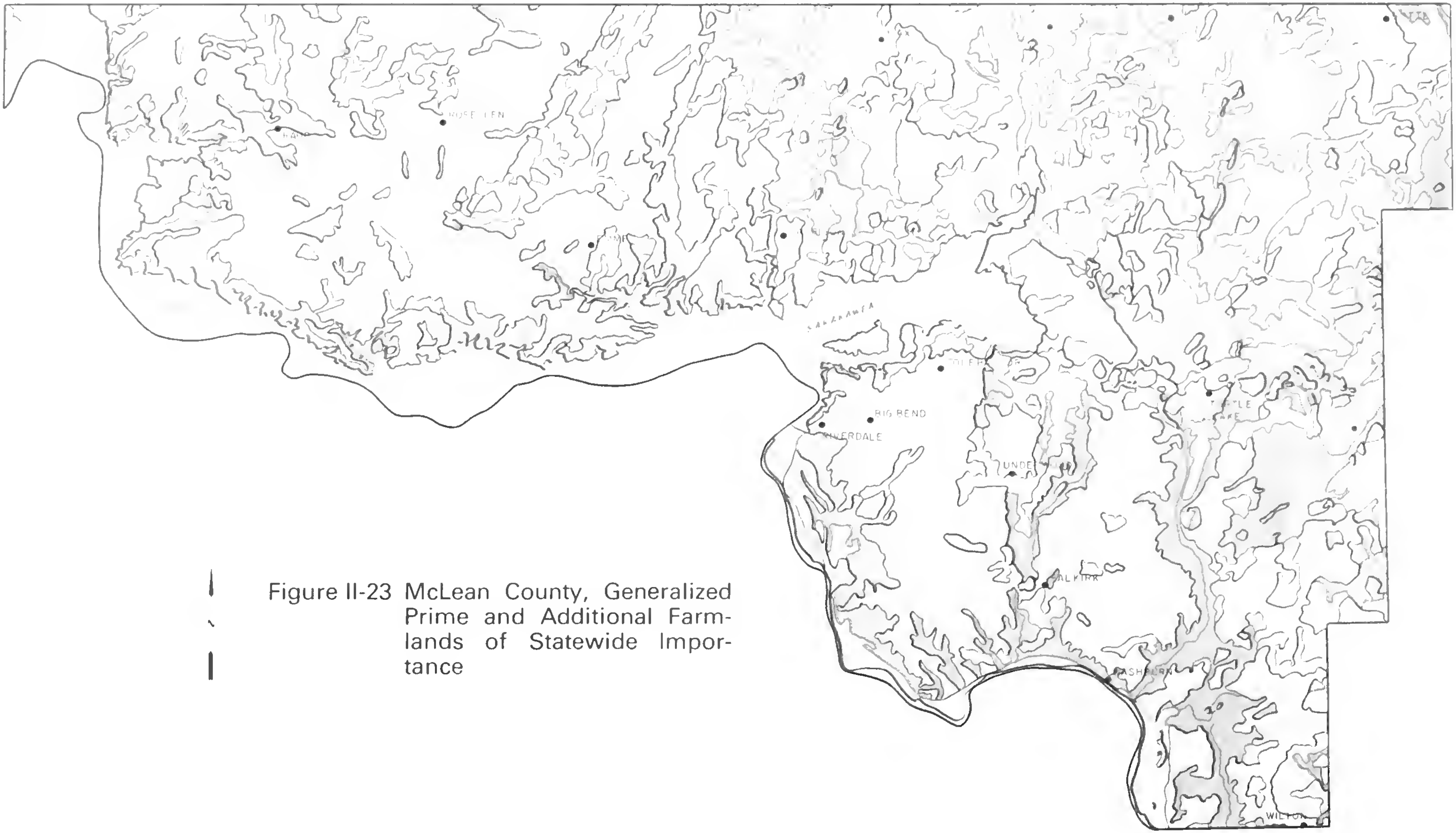


Figure II-23 McLean County, Generalized Prime and Additional Farmlands of Statewide Importance

McLEAN COUNTY

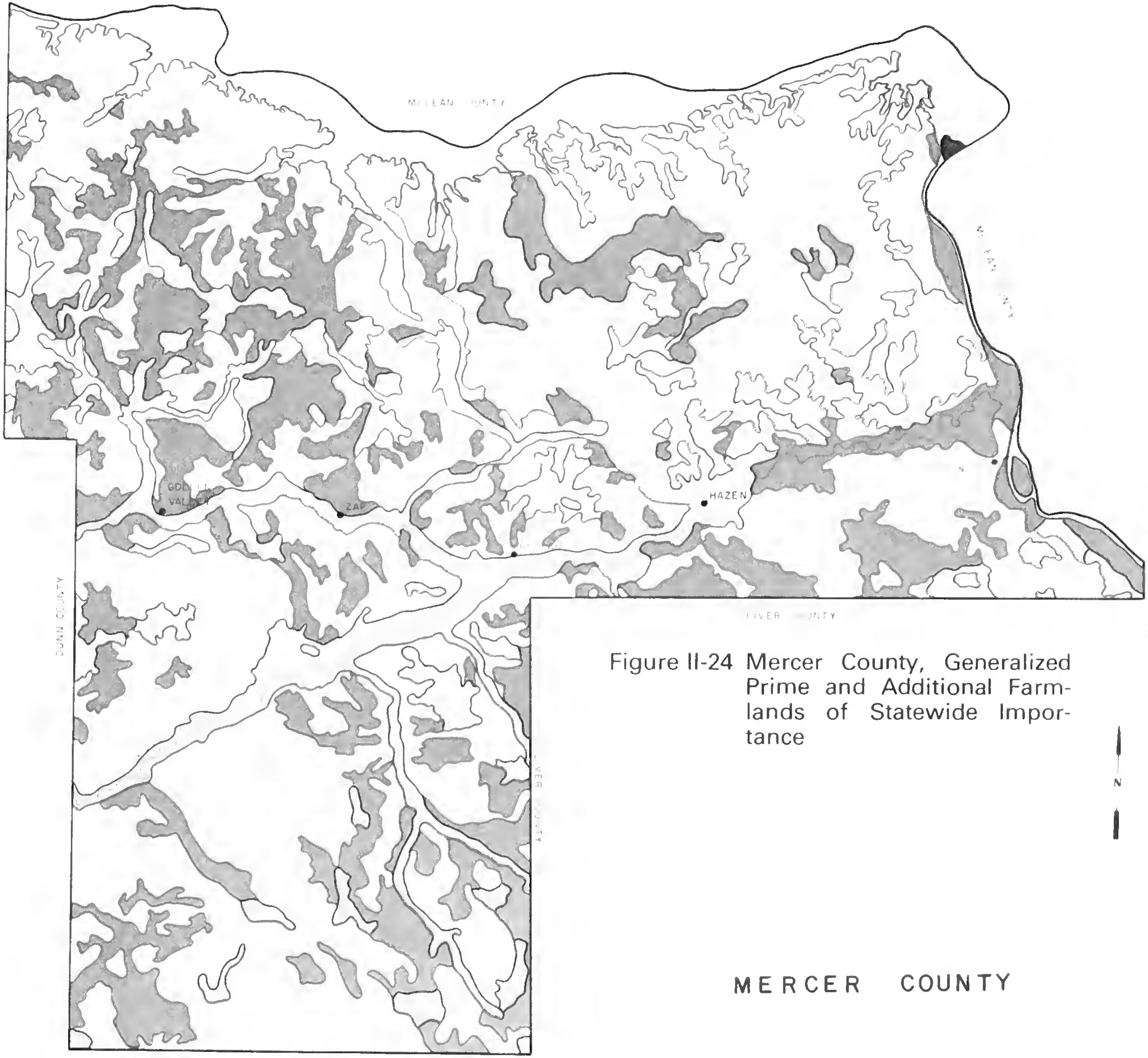


Figure II-24 Mercer County, Generalized Prime and Additional Farmlands of Statewide Importance

MERCER COUNTY

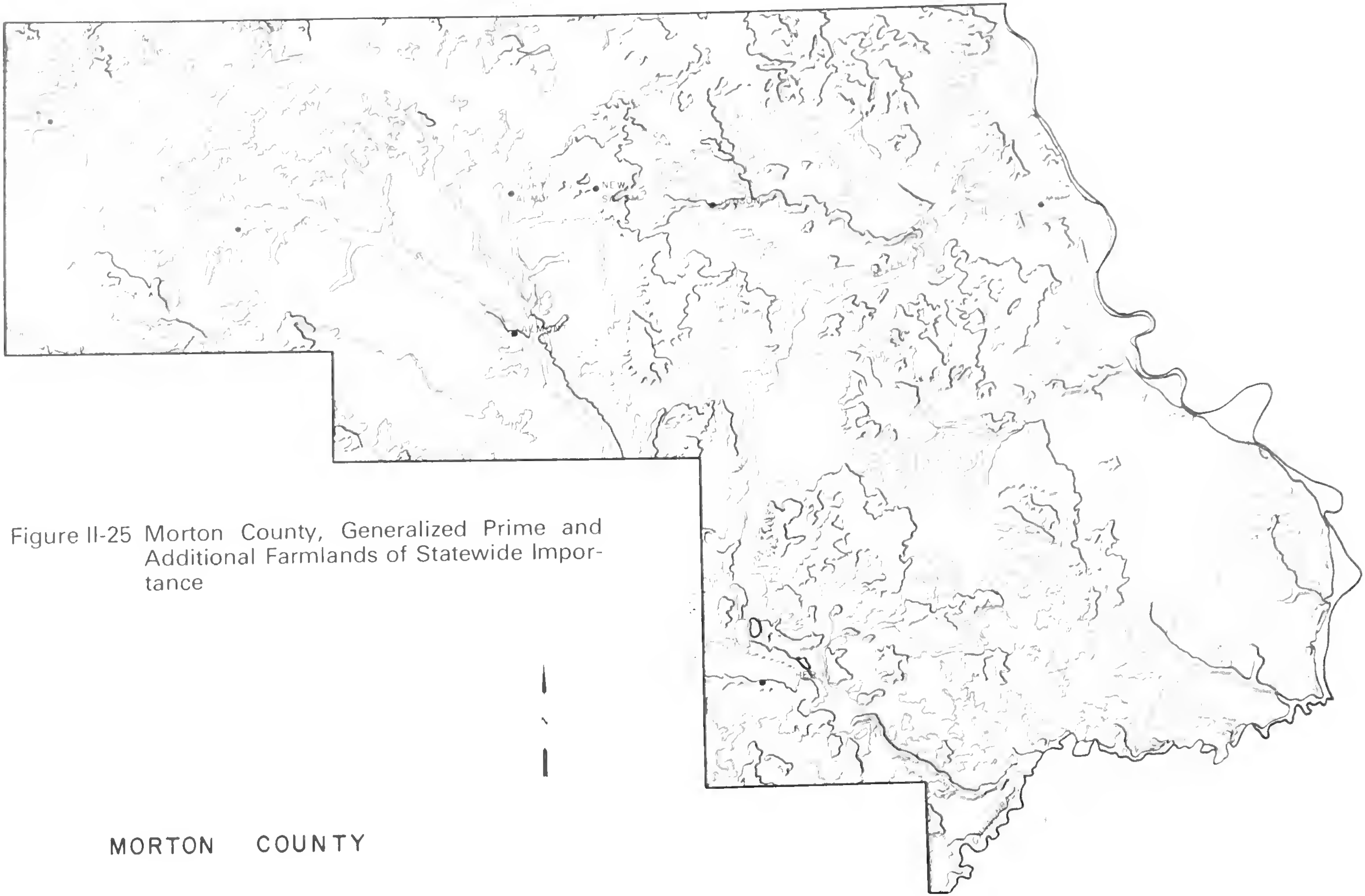
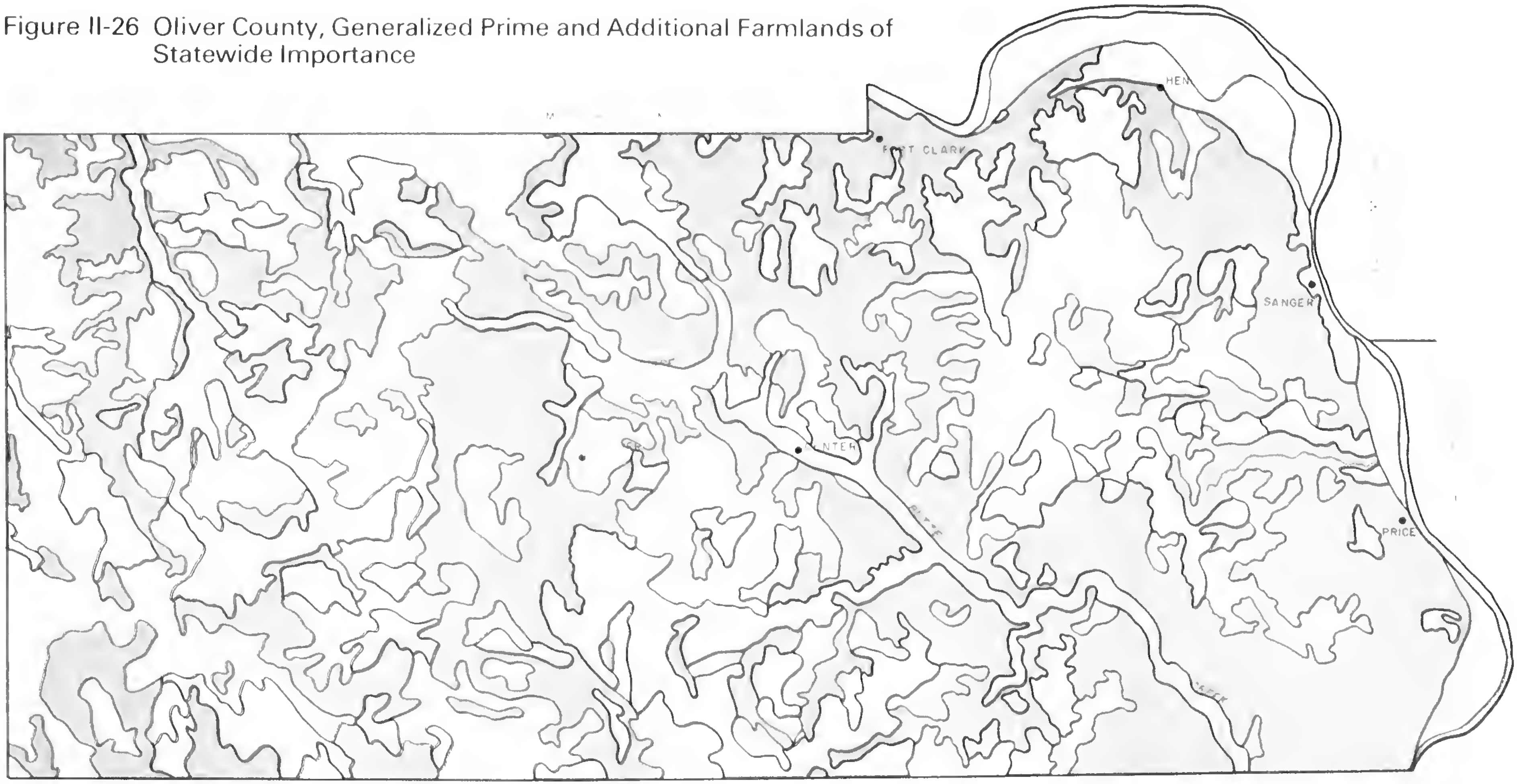


Figure II-25 Morton County, Generalized Prime and Additional Farmlands of Statewide Importance

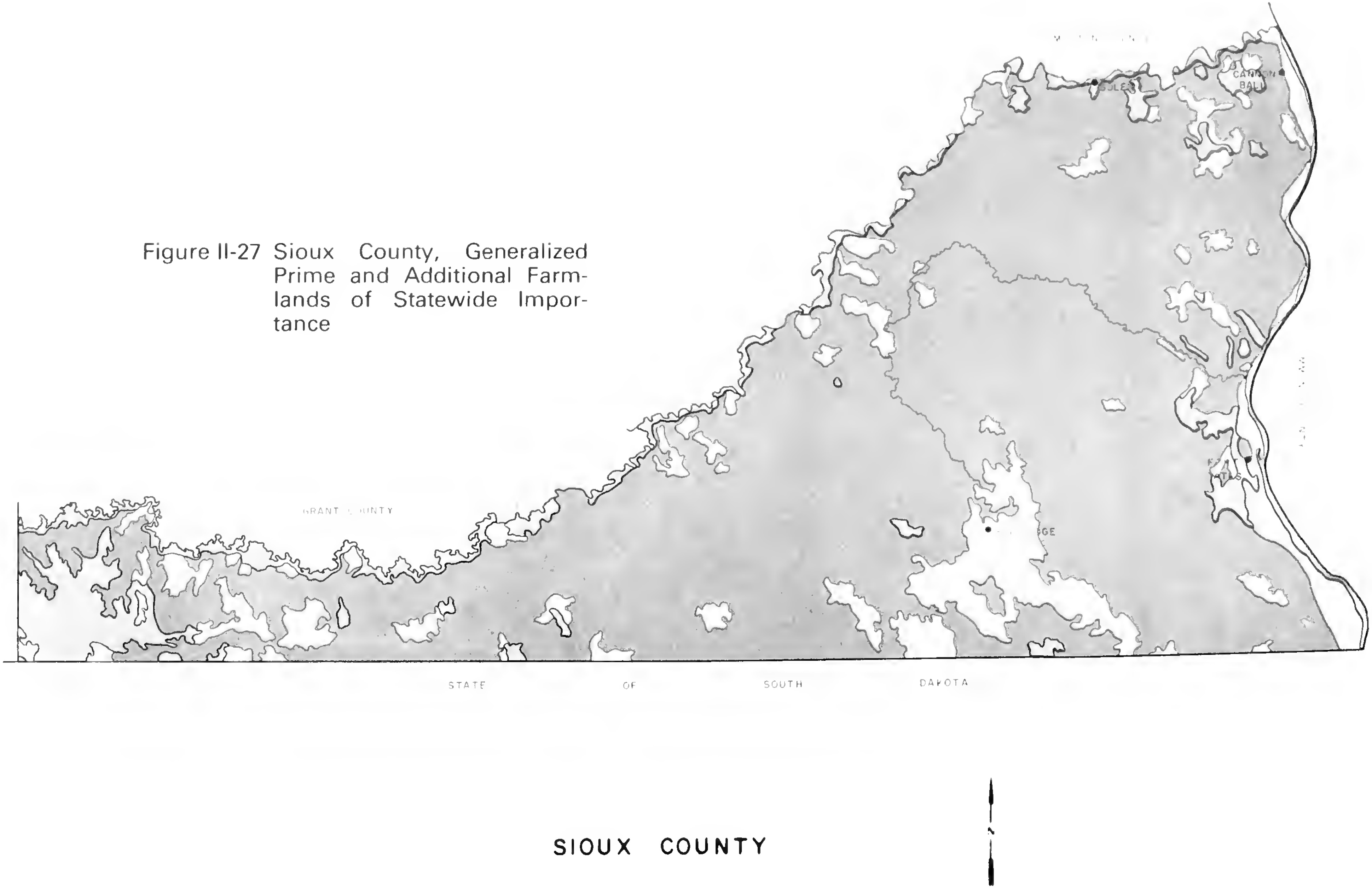
MORTON COUNTY

Figure II-26 Oliver County, Generalized Prime and Additional Farmlands of Statewide Importance



OLIVER COUNTY

Figure II-27 Sioux County, Generalized Prime and Additional Farmlands of Statewide Importance



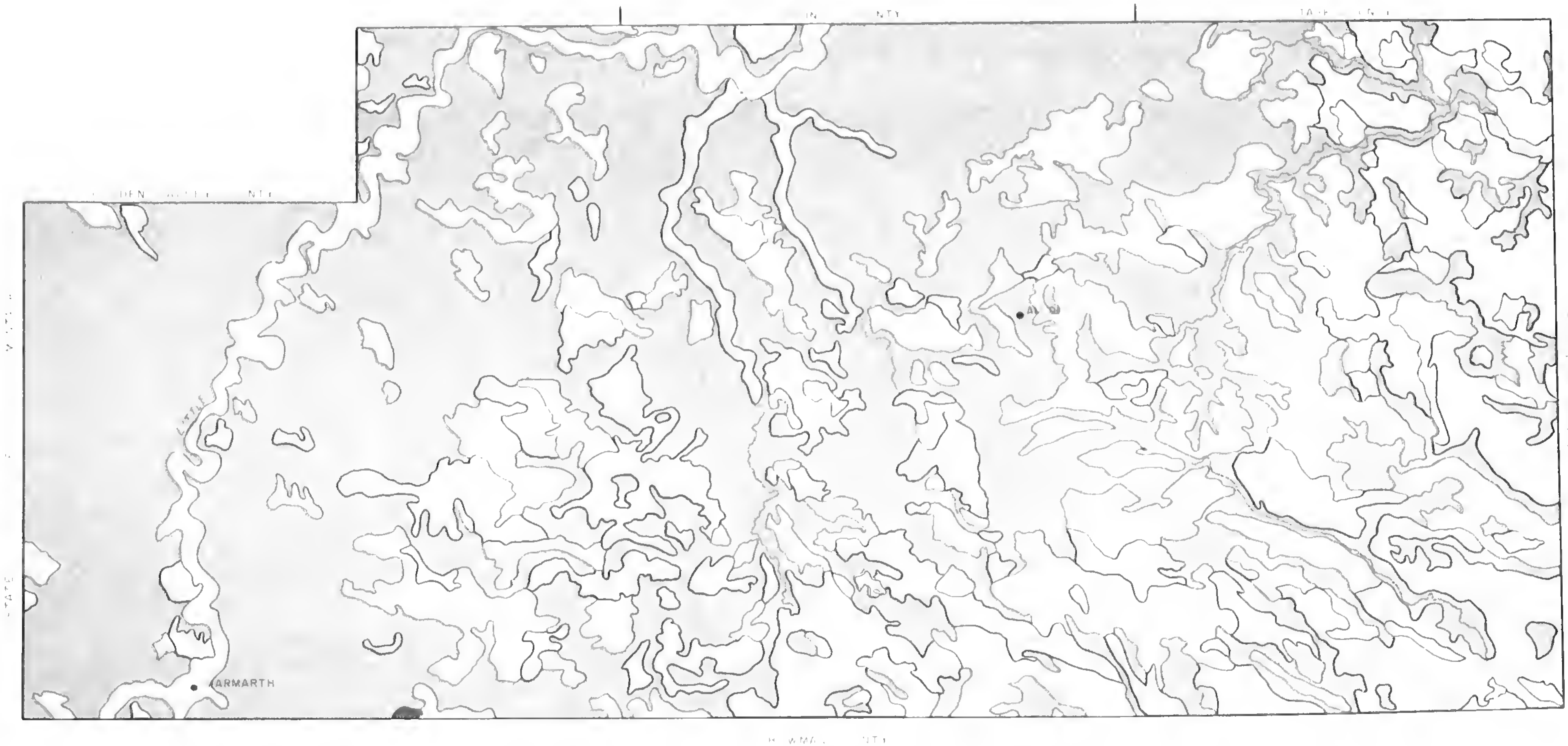


Figure II-28 Slope County, Generalized Prime and Additional Farmlands of Statewide Importance

SLOPE COUNTY

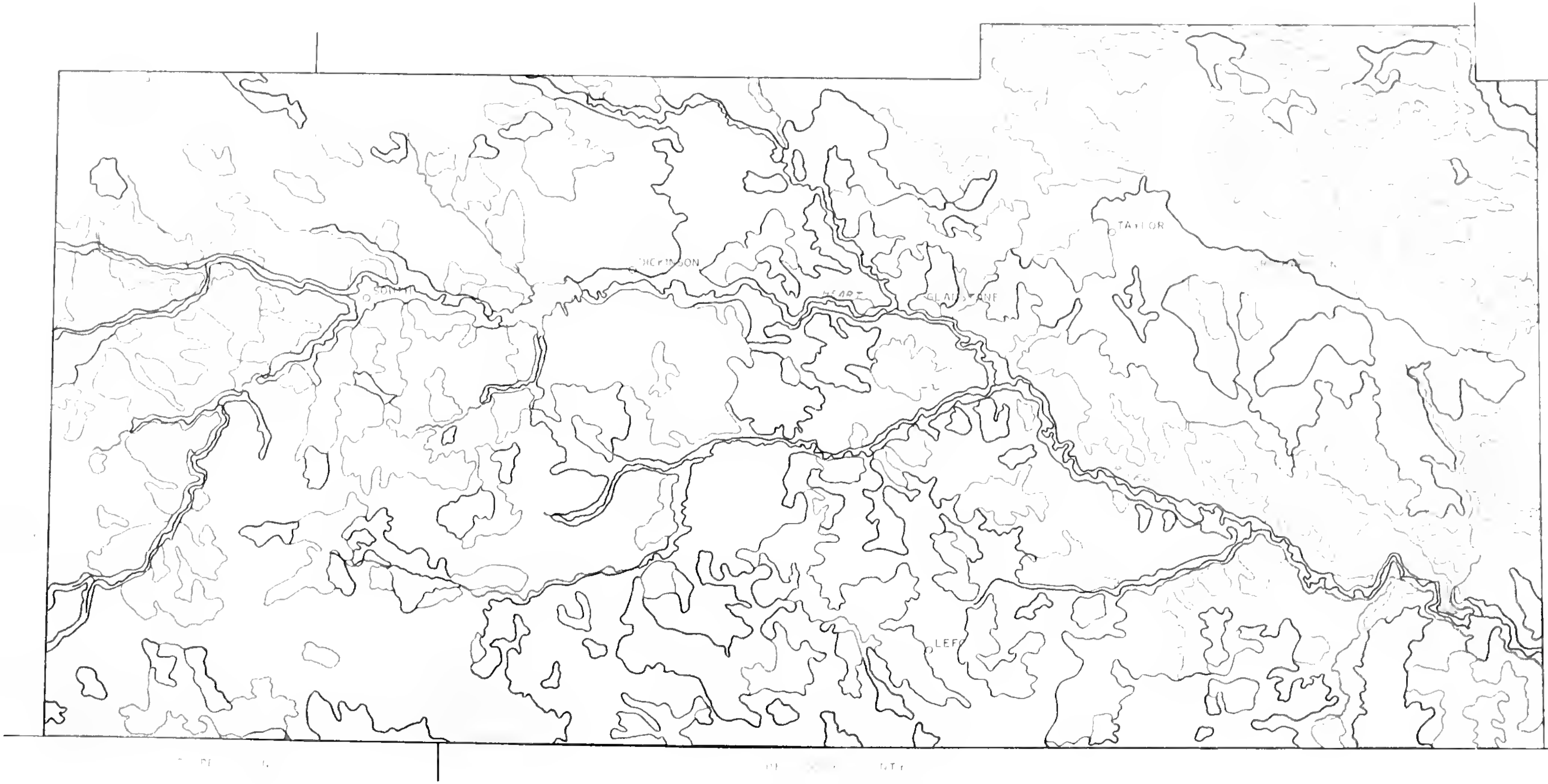


Figure II-29 Stark County, Generalized Prime and Additional Farmlands of Statewide Importance

STARK COUNTY

Mineral Resources

Mineral production is becoming increasingly important as a major source of income in the North Dakota Study Area. Petroleum, natural gas, and coal have in recent years accounted for over 90 percent of the area's mineral production. The remainder is from the production of sand and gravel, clay, stone, and small amounts of other mineral commodities.

Petroleum and Natural Gas

The Nesson Anticline, the largest single oil producing geologic structure in North Dakota, extends north from the Little Missouri River in northern Dunn County. Oil fields on the Nesson Anticline have produced most of the oil in the North Dakota Study Area (figure II-30). Near Dickinson, in Stark County, oil is trapped in beach and bar sands that were deposited along the south edge of the sea in the Williston Basin as it existed in late Mississippian and early Pennsylvanian time. At Rocky Ridge, south of Dickinson, the oil-bearing sand fills an ancient stream channel that was probably related to the beaches in the Tyler Formation of Pennsylvanian age. Farther to the southwest, in the Medicine Pole Hills Field in Bowman County, the oil has apparently accumulated in a reef in the Ordovician Red River Formation.

The Red Wing Creek Structure in McKenzie County was apparently formed by the impact of a meteor. Mississippian age strata are uplifted 3,000 feet above surrounding sediments of comparable age. The deformed Mississippian limestone, dolomite, and evaporites are underlain and overlain by relatively undeformed formations. Approximately 6,000 feet of geologic section is disturbed. The geologic structure is about 6 miles in diameter with a circular to slightly eliptical shape in plan view and a sombrero shape in cross-section view. Cumulative oil production in the counties in the North Dakota Study Area that produce oil is shown in table II-1.

Lignite

Lignite coal is found throughout the part of North Dakota that is underlain by Ludlow, Tongue River, and Sentinel Butte sediments (figure II-31). In

Figure II-30 LOCATION OF OIL FIELDS IN NORTH DAKOTA

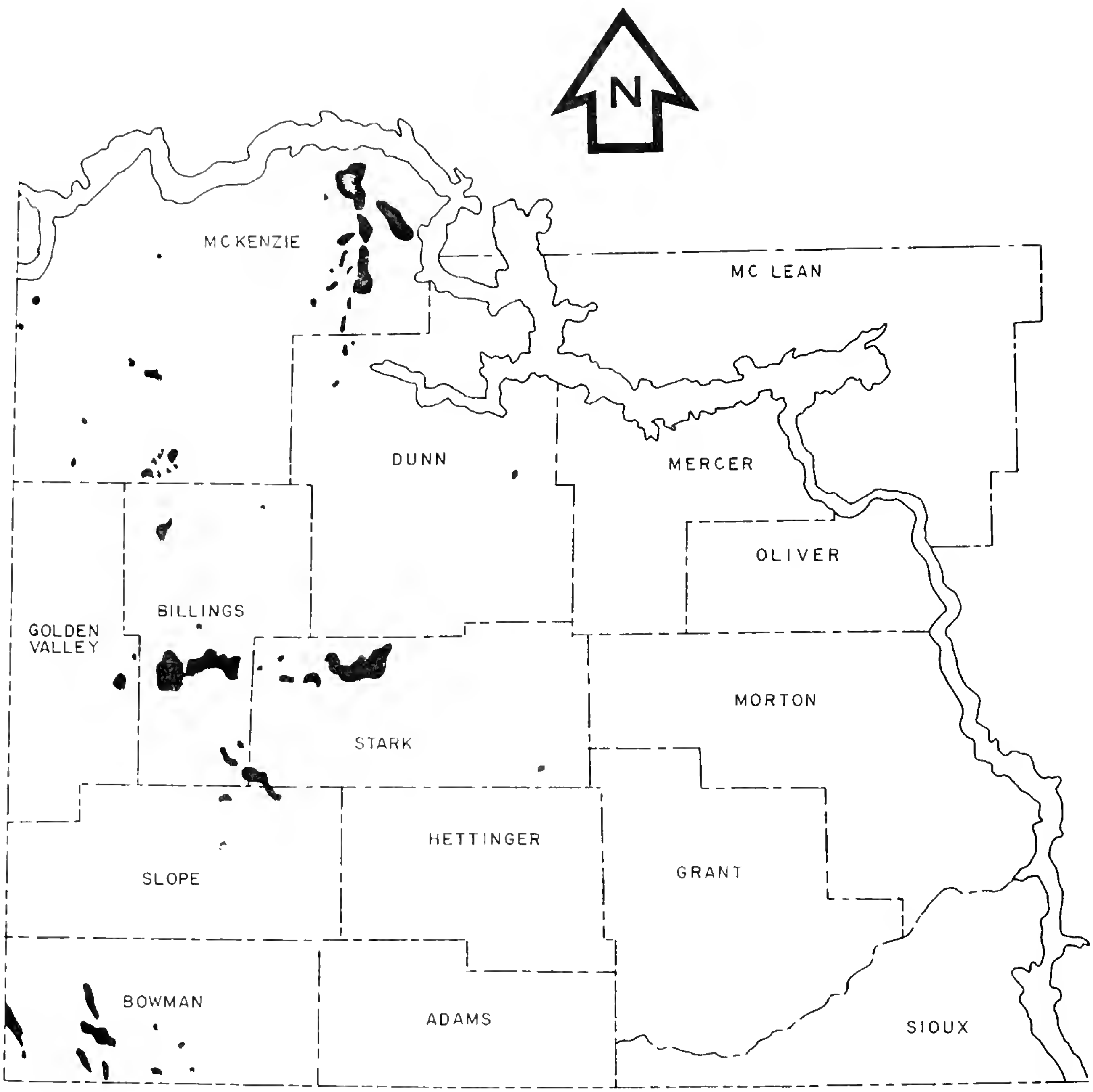
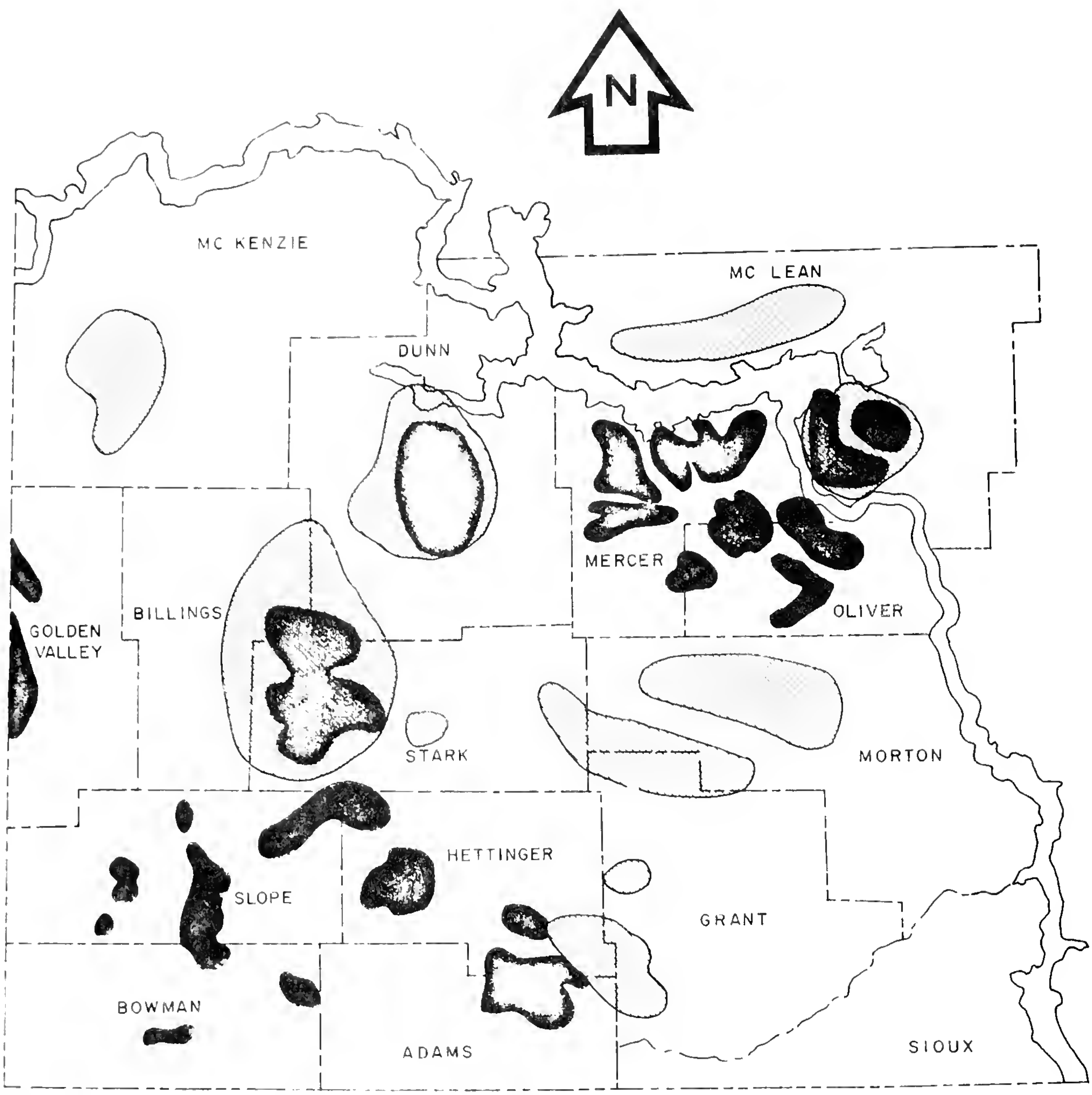


Table II-1. Oil Production by County

County	Cumulative Production (to 1-1-76) (barrels)
Billings	26,436,336
Bowman	13,616,757
Dunn	407,841
Golden Valley	426,107
McKenzie	105,209,897
Slope	895,571
Stark	13,109,618
Total	160,102,127

Source: North Dakota Geological Survey.

Figure II-31 LOCATION OF KNOWN LIGNITE DEPOSITS IN NORTH DAKOTA



Known strippable deposits

Known strippable deposits not well defined

general, lignite is a soft, low-rank coal. It consists of fragments of plants that grew in a warm and humid climate in ancient swamps that existed along streams that were flowing generally eastward from the newly formed Rocky Mountains during Paleocene time, about 65 million years ago. As the plants died and fell into the swamps, they began to decay due to the action of bacteria. When the streams changed course, they deposited sand on top of the partially decomposed vegetation. The overlying weight of sediment over long periods of time compacted and hardened the organic material to lignite coal. It took perhaps 150 years to accumulate enough material for a single foot of coal, and some of the coal beds in western North Dakota are up to 40 feet thick.

Production of lignite in the Study Area is currently centered in Mercer, Oliver, and Bowman Counties. Table II-2 lists the counties that have lignite resources and the strippable reserve for each county. Estimates of strippable reserves within the Study Area are about 14 billion tons in beds greater than 5 feet. In 1973, about 58 percent of North Dakota's lignite production was from Mercer County. Total production from the Study Area during 1975 was over 7 million tons.

Leonardite

Leonardite is associated with nearly all lignite deposits. It is formed by the natural weathering of lignite although it can be artificially produced by partial oxidation of lignite in air at relatively mild temperatures. Leonardite is a soft, earthy, medium-brown, coal-like material associated with most lignite outcrops in the State. It is a poor fuel, but it can be used as a source of chemicals and for other nonfuel uses. It has been used commercially in small amounts for many years for such purposes as a dispersant and viscosity control in oil-well drilling muds, as a stabilizer for ion-exchange resins in water treatment, as a soil conditioner, and as a source of water-soluble brown stain for wood finishing.

Table II-2. Strippable Lignite Reserves and Total Lignite Resource In The North Dakota Tributaries[1/]

County	Strippable Reserves[2/] (millions of tons)	Total Resources[3/] (millions of tons)
Adams	200	1 900
Billings	1 100	17 700
Bowman	800	7 000
Dunn	2 000	71 000
Golden Valley	300	8 300
Grant	100	4 700
Hettinger	1 000	12 600
McKenzie	800	32 200
McLean	1 000	16 500
Mercer	2 000	29 900
Morton	300	15 300
Oliver	600	17 800
Slope	2 300	20 100
Stark	1 300	25 700
TOTAL	13 800	280 700

1/ Source: North Dakota Geological Survey.
2/ The original strippable reserve estimates (the center column) refer to coal seams 5 feet or thicker and overburden of 100 feet or less.
3/ Total resources refer to coal seams at least 2 1/2 feet thick and overburden 1,200 feet or less.

Sand and Gravel

In terms of value, the production of sand and gravel ranks behind oil, gas, and lignite in North Dakota, but ahead of all other minerals. Sand and gravel are most readily available in the glaciated part of the Study Area, especially in McLean County. Extensive, sheetlike deposits of sand and gravel, known as glacial outwash, were deposited by numerous streams and rivers, which were fed by the melting glacier and by the large volumes of runoff from precipitation, which was much higher at the time than it is now.

Gravel found in terraces and in point bar deposits of modern streams is the only gravel available in much of the unglaciated portion of the Study Area. Some gravel was derived from rocks immediately upslope from where it was eventually deposited as alluvial fans and pediments. These deposits tend to be poorly sorted and, depending on the local source, they may contain shale, chert, or other detrimental materials. In some areas of southwest North Dakota where gravel is scarce, scoria and sandstone are mined and crushed for road surfacing material.

Uranium

The major North Dakota uranium occurrences are found in thin lignite beds that immediately overlie or underlie a sandstone that acted as an aquifer. Ground water moving through overlying sediments that contain uranium-bearing volcanic ash took the metal into solution as it moved through these sediments. Then, as the water containing the uranium moved through the aquifer, it came in contact with the lignite, and when it did so, the organic compounds in the lignite extracted and concentrated the uranium from the water.

Although uranium in lignite and related carbonaceous or organic material is fairly common, the only commercial American production from this source has come from the southwestern North Dakota and northwestern South Dakota area. Ore-grade uraniferous lignite was found in 1955 between Belfield and Amidon in southeastern Billings County. The first shipment of North Dakota ore was made from

this area in 1956, but only a few hundred tons were shipped from both North and South Dakota in the 1950's because the lignite was not amenable to milling by the methods applied to the common sandstone ore of the Colorado Plateau. From 1962 to 1967, uraniferous lignite of the Dakotas was burned in kilns or pits; the ash was then shipped to mills in South Dakota, Colorado, and New Mexico where it was blended and treated along with sandstone ores. Both the burning and mining had been discontinued by the end of 1967, apparently because market demand could be more profitably satisfied elsewhere.

Significant North Dakota production was limited to the Belfield area, where the deposits are clustered. The total production from North Dakota was listed by the U.S. Atomic Energy Commission as 85,138 tons of ore yielding 592,288 pounds of "yellow cake" (U_3O_8). At the four price levels now considered by ERDA, U.S. Bureau of Mines estimates of North Dakota Tributaries Planning Area uranium reserves would be:

Price per Pound	Tons of Ore 6/	Pounds of U_3O_8
$ 8	71,000	480,000
$10	144,000	892,000
$15	414,000	1,838,000
$30	1,000,000	2,384,000

Both production and reserve figures for North Dakota are far less than 1 percent of the total U.S. production and reserves.

With uranium currently becoming increasingly scarce, North Dakota's potential as a producer is attracting attention once again. Exploration for uranium in the state has been stepped up drastically and this renewed interest can be expected to continue.

Clay

Kaolinitic clays of potential economic importance are found in the Golden

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6/ Each price - reserve level includes all reserves at lower levels, i.e., the 1,000,000 tons of ore at $30 includes 414,000 tons, at $15 per pound as well as 586,000 tons at $15 - $30.

Valley Formation, especially in Stark, Morton, Hettinger, Dunn, and Mercer Counties. Montmorillonitic clay beds occur in the White River, Tongue River, Sentinel Butte, and Ludlow Formations in Stark, Slope, and Billings Counties in the Study Area. The Tongue River Formation contains some clay that could be mined economically if lignite is also being mined.

Light-burning Tertiary clays of the Golden Valley Formation have been used in the manufacture of face brick, building tile, and fire brick, with plants located at Dickinson and Hebron. Operations ceased at Dickinson in the late 1930's. A sewer pipe plant was opened at Dickinson in the early 1960's, but it operated only until 1970. The plant at Hebron is today the oldest (since 1905) and largest brick plant in operation in the State, producing 12 million brick units annually, utilizing about 36,000 tons of clay.

In 1953, a lightweight aggregate plant began operation at Mandan, producing aggregate from shale of the Cannonball Formation. A similar plant, opened in 1954 at Noonan, used clay occurring above a lignite seam in the Tongue River Formation. The latter plant was closed in 1971 because of freight costs. A third lightweight aggregate plant that began operations at Dickinson in 1968, utilizing clay from the Golden Valley Formation, is still in business (1975), producing 100 cubic yards a day during the summer months.

<u>Stone</u>

The stone industry in North Dakota deals mainly in crushed and broken stones. Sources in the Study Area include deposits of scoria, certain resistant sandstone beds in the Fox Hills Formation and Fort Union Group, and glacial boulders in glaciated areas such as McLean County. Only a small amount of stone classified under the category of dimension stone (blocks or slabs of natural stone that are cut to definite shapes and sizes) are presently produced in North Dakota. However, dimension stone has been quarried in a few places. Some sandstone beds of the Fort Union Group have been quarried and used for foundations in the Washburn

area. Some hard sandstone from the Taylor Butte area near Dickinson has been used for dimension stone. A sandstone bed in the Fort Union Group was quarried in northwestern Billings County, near the site of Theodore Roosevelt's Elkhorn Ranch. This stone was used mostly for indoor purposes such as fireplaces and decorative walls.

The value of stone produced in North Dakota in 1975 was $105,000. No sizeable sustained increase in the amount and value of stone produced in North Dakota is expected unless a cement industry utilizing limestone deposits is developed. Limestone in the White River Group of Oligocene age does occur at the surface in southwest North Dakota, but these deposits are too low in quality and too small to be considered for use in cement manufacture.

Gem Stones

The gem stones of southwest North Dakota are principally those formed by the precipitation of silica from cold water solutions. Moss agates are found in the gravels of the Yellowstone and Missouri Rivers in McKenzie County; petrified wood in the Hell Creek, Tongue River, and Sentinel Butte Formations in Billings, Adams, Morton, and Stark Counties; chalcedonic quartz in Stark and Hettinger Counties; agate in the Missouri River drainage throughout the southwest part of the State; and agatized fossil pine cones are recovered from the Hell Creek Formation near the junction of the Cannonball River and Cedar Creek in Grant County. Agate and chalcedony are recovered from glacial gravels in northeast Morton County. In addition, "rosettes" of marcasite crystals are found in the Tertiary coal beds in many places, and rhomboidal gypsum crystals are common in places in the Hell Creek Formation and in the Tertiary Ludlow Formation where they crop out in Morton County. At the current rate of production, the deposits of these gem materials are virtually inexhaustible.

Less well known materials of potential interest to the rock hobbyist occur in the State, and still other materials not yet known to occur or not now exploited might well be searched for. Glassy clinker from burnt coalbeds, similar

to obsidian and pitchstone, is apparently little used for gem purposes despite its attractive appearance. Prospecting could also be carried on for hard vitreous clots of coal from the vicinity of coal fires, which could be used like jet. The possibility exists that the bentonite beds in Stark and Bowman Counties, and elsewhere in the southwestern part of the State, may contain opaline quartz, barite concretions, celestite crystals, zeolites, and other gem materials.

North Dakota, having no surface exposures of igneous or metamorphic rocks in which deposits of the more valuable gem stones may have formed, is one of about 15 States each of whose current annual production of gem stones, as estimated over the years by the U.S. Geological Survey and the U.S. Bureau of Mines, has been $1,000 or less.

Sulfur

Sulfur is produced as a byproduct of North Dakota's gas-producing plants. Sulfur can be used in the manufacture of cellulose products, chemicals, dyes, fertilizers, iron and steel, pharameceuticals, rubber, and for water treatment. As of January 1, 1972, 451,345 tons of sulfur with a value of $10 million had been recovered.

Molybdenum

Molybdenum is a silvery-white metal with an extremely high melting point, approximately 2,620 degrees C. Its primary use is in steel alloys and stainless steel; however, its usage is increasing in the space, nuclear, and electronics industries. It is also used in the paint industry, in the manufacturing of some lubricants, and as a catalyst in petroleum refining.

In North Dakota, molybdenum is associated with uraniferous lignite deposits southwest of the Missouri River. Molybdenum was recovered as a byproduct from the uraniferous lignite from 1964 to 1968. No molybdenum production has occurred in North Dakota since the mining of uraniferous lignite ceased. The last reported production of molybdenum from the State was in 1968 from stockpiled uranium ore. Unless it becomes economically attractive to mine the uraniferous lignite again, there will probably be no further molybdenum production in North Dakota.

LAND USE

Agricultural Land Uses

The fact that the planning area is predominately agricultural is reflected in land use. Crop, pasture and rangeland[7/] make up about 93 percent of the area's 13,971,840 acres (table II-3). While crop production is a major land use, irrigated cropland is of minor significance to the region as a whole. Irrigation is important, however, to certain locales within the area.

Over 54 percent of the land has cover types that provide grazing for livestock. The latter implies that livestock production is an important element of the agricultural economy which is borne out by facts presented later in chapter 3.

About 40 percent of the total area is classified as cropland. All of these acres are not used to produce crops every year. For the base time period, over 3,671,000 acres were actually harvested for various crops (table II-4). Some of the cropland not harvested was fallow, some was used as pasture, some remained idle, and some was planted but not harvested due to crop failure. While harvested cropland has been increasing in very recent years, there are still fewer acres harvested than there were in the 1950's.

The distribtion of crops grown has remained relatively constant over time (table II-5). More acres of wheat are harvested each year than any other crop. During the base period (average of 1972-1974) most of the wheat grown (80.1 percent) was the spring variety. Only 4.3 percent of the harvested wheat was winter wheat and the remainder (15.6 percent) was durum.

Hay production is another important cropland use in the area. In the base period over 51 percent of the hay was alfalfa. The rest of the hay was tame grass hay, native hay and some small grain hay.

Feed grain production, primarily oats and barley, has come from 9 percent to 20 percent of the region's cropland. The acres devoted to feed grain production

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7/ Pastureland is defined as grazing land that contains introduced grass species versus rangeland that contains native grass species.

Table II-3. Major Land Uses for North Dakota Tributaries

	Base[1/] Acres
Total Cropland	5,597,075
Irrigated	54,510
Nonirrigated	5,542,565
Pasture	
Irrigated	1,490
Nonirrigated	311,680
Range	7,087,975
Forest Land	189,250
Urban & Builtup	170,620
Barren	204,700
Total Surface Area	13,971,840
Water Area	409,050
Land Area	13,562,790

1/ Based on report of land use update, Ad Hoc Work Group for Yellowstone River Basin and Adjacent Coal Areas, table 4. Irrigated cropland is different in that the number shown here represents an estimate of that actually irrigated in 1975. That estimate is 56,000 acres which is irrigated cropland (54,510) plus irrigated pasture (1,490).

Table II-4. Present and Historical Cropland Use
North Dakota Tributaries

	Base 1/	1949 2/	1954 2/	1959 2/	1964 2/	1969 2/	1974 3/
				Thousand Acres			
Harvested Cropland	3,676	4,171	4,398	3,968	3,522	3,333	3,644
Pasture	313	237	139	204	227	627	707
Fallow Cropland	1,737	893	1,040	1,118	1,473	2,104	1,593
Other Cropland	184	600	233	473	474	320	225
Total Cropland & Pasture	5,910	5,901	5,810	5,763	5,696	6,384	6,169

1/ Base was determined from table 4, Report of Land Use Update, Ad Hoc Work Group; table 6, Report of Agricultural Ad Hoc Work Group and 1973-1975 average of barley and wheat acres planted on fallow ground as reported by SRS, USDA.
2/ From U.S. Dept. of Commerce, Bureau of the Census, Census of Agriculture for appropriate years. Pasture is cropland used only for pasture as reported by Census.
3/ From U.S. Dept. of Commerce, Bureau of the Census, preliminary reports for 1974 Census of Agriculture except "fallow", which is 1975 preliminary estimate of acres of barley and wheat planted on fallow land as reported by SRS, USDA.

Table II-5. Cropping Pattern for Major Harvested Crops 1/
North Dakota Tributaries

Crop	Percent of Total Harvested Acres					
	1949	1954	1959	1964	1969	Base
Wheat	55.0	42.6	39.9	42.5	46.3	45.0
Rye	.4	1.2	.8	1.6	1.0	.5
Corn for Grain	1.2	1.4	.1	.2	.2	.1
Silage	6.0	7.8	12.0	8.5	4.4	2.8
Oats	5.1	8.5	5.8	10.7	13.6	12.5
Barley	2.8	6.3	9.9	7.4	5.3	7.5
Hay	22.2	19.5	27.5	25.5	24.9	29.8
Flaxseed	5.5	11.6	2.8	2.8	2.8	1.5
Sugar Beets	.1	.1	.1	.2	.3	.2
Irish Potatoes	.1	.05	.03	.02	.08	.07
Dry Beans	0	.03	.05	.08	.06	.05
Other	1.6	.92	1.02	.5	1.06	-

1/ Based on table 2 of Report of Agricultural Ad Hoc Work Group, Yellowstone River Basin and Adjacent Coal Areas, Level B.

have risen over time apparently in a manner similar to the increase in cattle production.[8/]

The other crops grown take up a relatively small percentage of the total cropland acres. Some of these other crops, however, are very important to some localities within the study area. For example, sugar beets are grown on less than 1 percent of the cropland; however, all those acres are concentrated within a small geographical area. Economically, this acreage is quite important to the existant farms.

Other Land Uses

Just a little over 1 percent of the land area (170,620 acres) is in urban and built-up uses (table II-3). These uses include highways and roads, as well as cities and towns. Over 189,000 acres of land are classified as forest covered. Both coniferous and deciduous forest is included in this acreage. These lands provide important habitat for wildlife and forage for domestic wildlife. Timber values for these lands are considered only marginal. The forested lands constitute an important recreational and aesthetic resource in an area characterized by prairie terrain. Barren areas cover about 205,000 acres. Much of this acreage is contained in the Little Missouri Badlands along the Little Missouri River. Although these lands provide few benefits to agriculture, they are an important source of scenic and recreational values, as exemplified by Theodore Roosevelt Memorial National Park. Surface water occupies over 400,000 acres in the planning area. Almost all of this acreage is included in Lake Sakakawea, Lake Ilo, Lake Tschida, Patterson Lake and Bowman Haley Reservoir. Other water areas consist of the western tributary streams and small reservoirs used for livestock watering. Water bodies under 40 acres in size occupy less than 25,000 acres. This scarcity of surface water creates livestock distribution problems on some rangelands. With the exception of Lake Sakakawea, large areas of surface water are exceedingly scarce in the area.

8/ The number of head of all cattle in the area has risen from about 492,000 in 1949 to over 1,000,000 in the base period. See chapter 3 for further discussion.

Land Ownership

Almost 89 percent of the North Dakota Tributaries area is in non-Federal ownership (table II-6). The latter is one of the characteristics that makes this planning area quite different from some of the others. The U.S. Forest Service administers the largest block of the Federal land. The majority of the Forest Service lands is in the Little Missouri National Grasslands in the western part of the study area.

Interestingly, the U.S. Army Corps of Engineers administers the second largest amount of surface acres. Most of these acres are represented by Lake Sakakawea, which was formed by Garrison Dam. There are over 409,000 acres of water in the study area, but 378,400 of these acres are under Federal administration.

The National Park Service lands consist mainly of the Theodore Roosevelt National Memorial Park units near Medora in Billings County and south of Watford City in McKenzie County. The Park Service has also acquired some land that contains historic Indian village sites along the Knife River.

Several other Federal agencies administer some land in the area. However, these lands are a small part of the total study area.

Fish and Wildlife

Endangered Species

The Endangered Species Act (Public Law 93-205) was passed by Congress in 1973. Under provisions of the Act, two categories of endangerment were recognized: (a) those species in danger of extinction throughout all or a significant portion of their range (i.e., Endangered Species); and (b) those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range (i.e., Threatened Species). Two of the primary purposes of the Act were to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved," and "to provide a program for the conservation of such endangered species and threatened species." The Act placed a heavy responsibility on all Federal agencies to pro-

Table II-6. Land Ownership 1/
North Dakota Tributaries

	Acres	
Nonfederal	12,382,959	
Private (including county & municipal)		11,308,831
State		379,708
Indian 2/		694,420
Federal	1,588,881	
Forest Service		1,034,449
Corps of Engineers		389,424
National Park Service		70,980
Bureau of Land Management		55,594
Bureau of Reclamation		23,754
Fish & Wildlife Service		9,498
Bureau of Indian Affairs		4,000
Agricultural Research Service		1,119
Military		63
Total Surface Area	13,971,840	

1/ Source is Table 2B of Report of Land Use Update, Ad Hoc Work Group, September 1976.
2/ Land owned by Indians, the title of which is held in trust by the U.S. Government.

tect species and their critical habitat determined by the Secretary of the Interior to be in danger of extinction. Section 7 of the act states:

> "All other Federal departments and agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of purposes of this Act by ... taking such action necessary to insure that actions authorized, funded or carried out by them do not jeopardize the continued existence of such endangered species and threatened species or result in the destruction or modification of habitat of such species which is determined by the Secretary after consultation as appropriate with the affected states, to be critical."

The Interior Secretary has delegated to the Fish and Wildlife Service the responsibility of coordinating programs involving the management of endangered species. Recovery plans, developed by recovery plan teams, have been selected as a means to combine the varied knowledge and programs of different agencies and organizations into single, effective concentrated efforts. The ultimate goal of each recovery team is to develop a plan which will restore an endangered or threatened species as a viable self-sustaining member of its ecosystem. The immediate goal for many species, however, is to develop a plan which will prevent extinction.

The concept of "critical habitat" or living space needed by each animal listed as an endangered or threatened species, as envisioned by the Fish and Wildlife Service, was published in the April 22, 1975, issue of the Federal Register. The following vital needs are considered as relevant in determining critical habitat for any given species:

1) Space for normal growth, movements, or territorial behavior;
2) Nutritional requirements, such as food, water, minerals;
3) Sites for breeding, reproduction, or rearing of offspring;
4) Cover or shelter; or
5) Other biological, physical, or behavioral requirements.

Three animal species on the Federal endangered list are known to occur within the

North Dakota portion of the Yellowstone Level B project study area. Endangered species are the American peregrine falcon (<u>Falco peregrinus anatum</u>), the black-footed ferret (<u>Mustela nigripes</u>) and the Whooping Crane.

Only limited information is readily available that pertains to the present distribution or habitat requirements of the above listed species in the study area. However, recovery teams have been established for each of the endangered species. Information compiled and/or developed by these groups should be available in the future to help guide planning efforts.

The black-footed ferret is associated primarily with mid and short grass prairie areas. Its original range covered most of the western one-half of North Dakota. Although ferrets have been found in various habitat types, the majority of evidence to date indicates their primary natural habitat is prairie dog colonies. The historic range of the ferret nearly coincided with the combined range of the black-tailed and white-tailed prairie dogs. Thus, all prairie dog towns must be suspected of providing ferret habitat unless and until field investigations prove otherwise.

Within the North Dakota portion of the Level B Study Planning Area, reported sightings have been recorded for both the peregrine falcon and the black-footed ferret. Ferret habitat in the form of prairie dog towns occurs in several counties comprising the planning area. In the near future, all dog towns and areas that possibly provide habitat for falcons should be surveyed for the possible occurrence of the animals.

In addition to reported observations of peregrine falcons and black-footed ferrets, confirmed sightings of the endangered whooping crane have been recently reported in the planning area; primarily in McLean County. In accordance with provisions of the Endangered Species Act, the Interior Secretary will make the final "critical habitat" determination for all threatened and endangered species.

<u>Migratory Birds</u>

Migratory birds in the Yellowstone Level B Study Area are a renewable natural

resource that provide recreation in various forms for thousands of people. Although renewable, the resource is not limitless, and careful surveillance and management are needed to keep populations in harmony with other land and water uses.

A wide variety of migratory birds, occurring in the study area during some seasonal period each year, utilizes most available terrestrial and aquatic habitat types. Although the exact species composition of each individual planning area or the entire study area is not known, populations of ducks, geese, shorebirds, and cranes representing almost every species on the North American continent pass through the basin on their way to and from nesting and wintering grounds. Some species of these groups also nest in the area. Many other additional species from other bird groups, including Falconiformes, Gaviiformes, Gruiformes, Columbiformes, Strigiformes, Piciformes, and Passeriformes also migrate through the basin. Likewise, portions of the basin serve as important breeding and wintering areas for some species of these groups.

The Fish and Wildlife Service is the Federal agency which has primary responsibility for the overall welfare of migratory birds. The species' well-being is accomplished in accordance with provisions of certain legal documents. The "Migratory Bird Treaty Act" is the basic legislation which provided authority for managing and preserving migratory birds. This act implemented treaties with Great Britain (for Canada) and Mexico for the Federal preservation of migratory birds. It also provided the authority for regulating the taking, selling, transporting, and importing of such birds. Other important legal documents which help provide for migratory bird needs include the "Migratory Bird Conservation Act," "Migratory Bird Hunting Stamp Act," and the "Convention between the United States and the United Mexican States for the Protection of Migratory Birds and Game Mammals."

The mission of the Fish and Wildlife Service in reference to this particular resource is to perpetuate the resource through wise use and sound management. This is accomplished through extensive cooperative efforts (emanating in part

from legal documents cited above) with States, Canadian and Mexican natural resource agencies as well as the private sector.

There are four primary objectives of the Fish and Wildlife Service migratory bird program. They are to:

1) Preserve and increase natural habitat for birds.

2) Control hunting mortality to avoid over exploitation and reduce other losses.

3) Develop cooperative management activities with other wildlife agencies.

4) Increase public understanding of migratory birds and their needs.

Included among the work programs designed to achieve these objectives is the acquisition of suitable lands and operation and maintenance of national wildlife refuges and wetland management districts. These areas provide nesting, migrating and wintering habitat for waterfowl and other migratory birds, both game and nongame species.

Within the North Dakota Tributaries area there are 10 national wildlife management areas (refuges); 1 each in Dunn and Grant Counties, 2 in Slope County, and 6 in McLean County. In addition, approximately 20,000 acres of "waterfowl production areas" exist in McLean County. Garrison Dam National Fish Hatchery is also located in this planning area.

Outdoor Recreation Resources

A variety of outdoor recreation opportunities can be found throughout the study area. No matter what season of the year, there are always exciting activities to be enjoyed in the out-of-doors. Due to the low population in the study area, some people do have to travel some distance to take part in their favorite outdoor recreation activity. State, Federal, county and municipal governments, as well as the private sector have provided the supply of outdoor recreation opportunities.

For planning purposes, the varied activities within the study area are

divided into three catagories. They include the following:

1. Facility-oriented activities (Participants in these outdoor recreation activities usually require a special area or facility); picnicking, camping (both recreational-vehicle and primitive), baseball, softball, golf, tennis, archery, horseshoes, volleyball, basketball, range shooting, swimming (both at beaches and at pools), powerboating, sailing, water-skiing, ice hockey, ice skating, snow skiing, and sightseeing (both scenic and historic).

2. Resource-oriented activities (Participants in these activities depend on careful management of natural resources, and often the numbers of persons who use them); fishing, ice-fishing, and hunting (waterfowl, upland game, big game, and nongame).

3. Recreation trail activities (Participants use existing trails or roads, but special trails may be used or should be provided). For such activities, it is difficult to separate recreational use from transportation use: bicycling, snowmobiling, sledding, horseback riding, hiking, canoeing, cross-country skiing, snowshoeing, and off-road motorcycling.

Within the study area, several recreation sites have been developed by State, Federal, and local government, plus the private sector. They provide a wide assortment of recreation activities. Most of these are water-based recreation activities created by the impoundment of the Missouri River into Lake Sakakawea and Lake Oahe. In addition, the Theodore Roosevelt National Memorial Park and six State parks within the study area provide an opportunity to enjoy natural scenic wonders and to commune with nature.

The designation of the Little Missouri State Scenic River by North Dakota has preserved the river for recreational enjoyment of the people. The planning area also contains more than 450 miles of canoeing waters, including 22 miles of the Yellowstone, 36 miles of the Knife, 106 miles of the Heart, and 45 miles of the Cannonball rivers, and 274 miles of the Little Missouri. Within the planning area

are over 150 miles of established trails for year-around recreational use. Many areas within the region are sparsely populated, accessible by primitive roads or wheel tracks, and in dry weather provide opportunities to enjoy the prairie or badlands environment. There is a great need for this type of recreation opportunity. Thus, efforts must be made to protect this invaluable natural resource.

The planning area is also rich in history. There are five national and 18 State historic sites within the study area, plus such historic towns as Medora. In addition, many local communities and the private sector provide museum, historic displays, and historic adventure. These all provide opportunities to view the past, and to even live it in some cases.

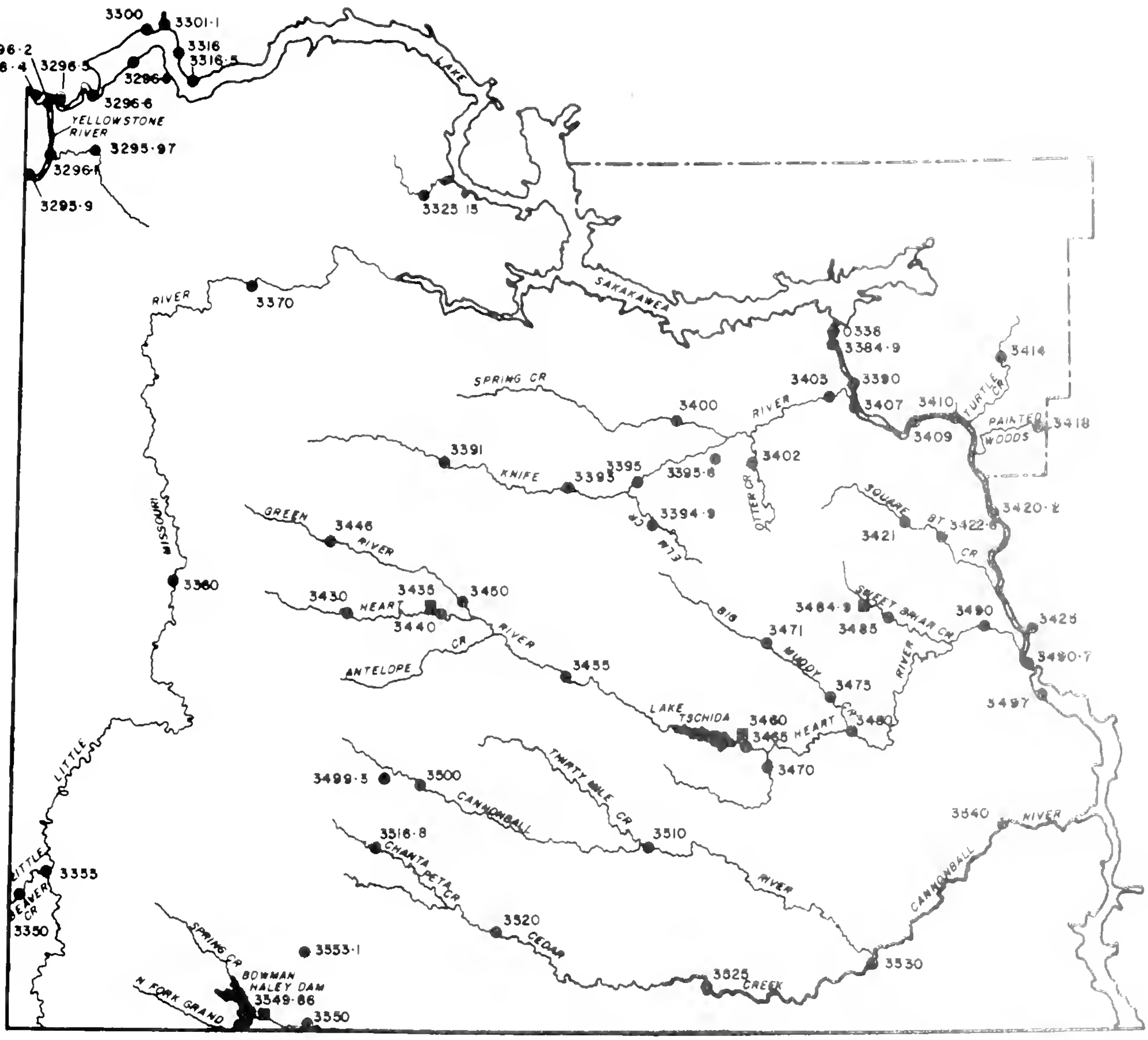
There are, within the planning area, several unique and natural phenomena such as the burning coal veins and columnar juniper which provide recreational enjoyment. These natural and unique areas must be preserved and protected. The 1975 North Dakota Legislature did provide for the preservation of these areas by passing the Nature Preserve Act, and the areas are now in the process of being selected and so designated.

Surface Water

Streamflow Records

The earliest measurement of streamflow in western North Dakota was recorded on the Missouri River in 1897. In 1903, the United States Geological Survey became active in streamflow measurements in North Dakota, and since the early 1930's the State of North Dakota has cooperated with the U.S.G.S. in conducting streamflow measurements. When the North Dakota State Water Commission was established in 1937, it was designated as the lead State agency to cooperate with the U.S.G.S in the stream gaging program. Locations of the stream gaging stations in the planning area are shown in figure II-32.

Figure II-32. Stream and Lake Gaging Locations (1975)
North Dakota Tributaries



Historic and Estimated Streamflows

Runoff from the mountains and foothills of Montana and Wyoming is the principal source of supply for the Missouri River at Williston. Approximately 55 percent is contributed by the Yellowstone River and 45 percent from the Missouri River above the Yellowstone confluence. Approximately two-thirds of the total streamflow at the Williston gaging station is generated in Montana with the remainder coming from Wyoming. The estimated average annual flow past Williston between 1898 and 1964 was 16,890,000 acre-feet.

Based on records for a period of 46 years between 1928 and 1975, the average flow in the Missouri River at Bismarck was 16 million acre-feet. The lowest volume of flow occurred in 1931, and was 9.4 million acre-feet. The highest volume of flow occurred in 1975, and was 25.8 million acre-feet.

Streamflow records in the planning area vary in length from less than 10 years to over 40 years. Due to the lack of continuity of the streamflow records, a computer program was used in the West River Study 9/ to analyze recorded historic flows and generate streamflows where gaps existed. This method provided continuous streamflow data for the years 1903 to 1972 for most gaging stations. The computer program (HEC-4) was obtained from the Hydrologic Engineering Center of the U. S. Army Corps of Engineers. The program assumes hydrologic integrity from one location to another.

The major portion of the runoff in streams in the planning area originates from snowmelt. It is estimated that approximately two-thirds of the annual flow in the rivers is derived from snowmelt and the remainder from rainfall. Figure II-33 illustrates the average annual runoff per square mile for the planning area. The annual flow generally decreases from north to south. It is estimated that the total runoff in the planning area averages 800,000 acre-feet annually.

9/ The West River Study. North Dakota State Water Commission. July, 1975.

Figure II-33 Average Annual Runoff in Acre-Feet/Mile²

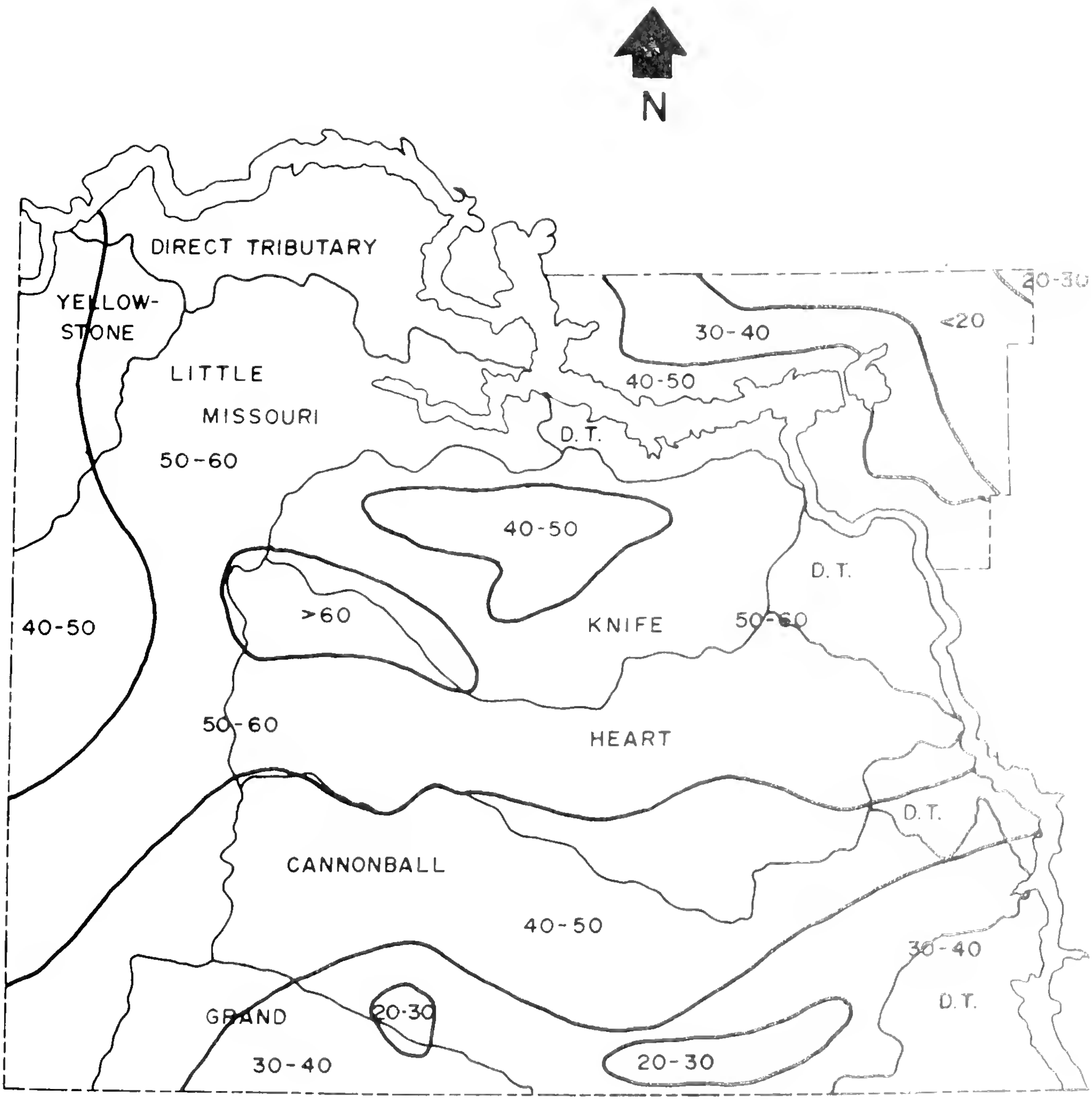


Table II-7 indicates the high, average and low flow at selected locations.

Figures II-34 through II-38 show the historic and estimated runoff for selected gaging stations in the planning area and for the Missouri River. The wet and dry cycles are readily discernable.

Table II-8 presents the monthly distribution of the average streamflows for selected gaging stations. While the major tributary rivers usually peak in the spring due to the snowmelt, the Missouri River above Garrison Dam usually peaks twice -- once in the March-April period from snowmelt from the plains area and again, in the June-July period from the mountain snowmelt. The peak from mountain snowmelt is usually higher than the earlier peak.

Table II-7 - Annual Runoff in Acre-Feet, at Selected Locations
North Dakota Tributaries

Location (Stream gage Number)	Recorded Historical Average (Period of Record)	Estimated Long Term Average (1903-1975)	High Flow (year)	Low Flow (year)
Knife River at Hazen (3405)	131,200 (1930-33;1937-75)	123,400	339,000 (1912)	20,700 (1961)
Heart River at Mandan (3490)	185,800 (1928-32;1937-75)	169,100	499,200 (1950)	15,300 (1961)
Cannonball River at Breien (3540)	177,400 (1934-75)	153,900	719,600 (1950)	7,200 (1961)
Little Missouri River near Watford City (3370)	438,500 (1935-75)	435,000	1,185,000 (1971)	58,400 (1961)
Grand River near Haley (3550)	21,300 (1909-17;1946-75)	18,500	110,400 (1969)	1,100 (1961)
Turtle Creek near Turtle Creek (3414)	525 (1957-75)	475	1,450 (1972)	29 (1961)
Painted Woods near Wilton (3418)	5,500 (1958-75)	4,950	17,200 (1972)	302 (1961)
Missouri River at Bismarck (3425)	16,000,000 (1928-1975)	--	25,800,000 (1975)	9,420,000 (1931)

1. Water Year: from October of preceding year to the end of September of year listed

Figure II - 34 - HISTORIC AND GENERATED FLOWS
KNIFE RIVER NEAR GOLDEN VALLEY

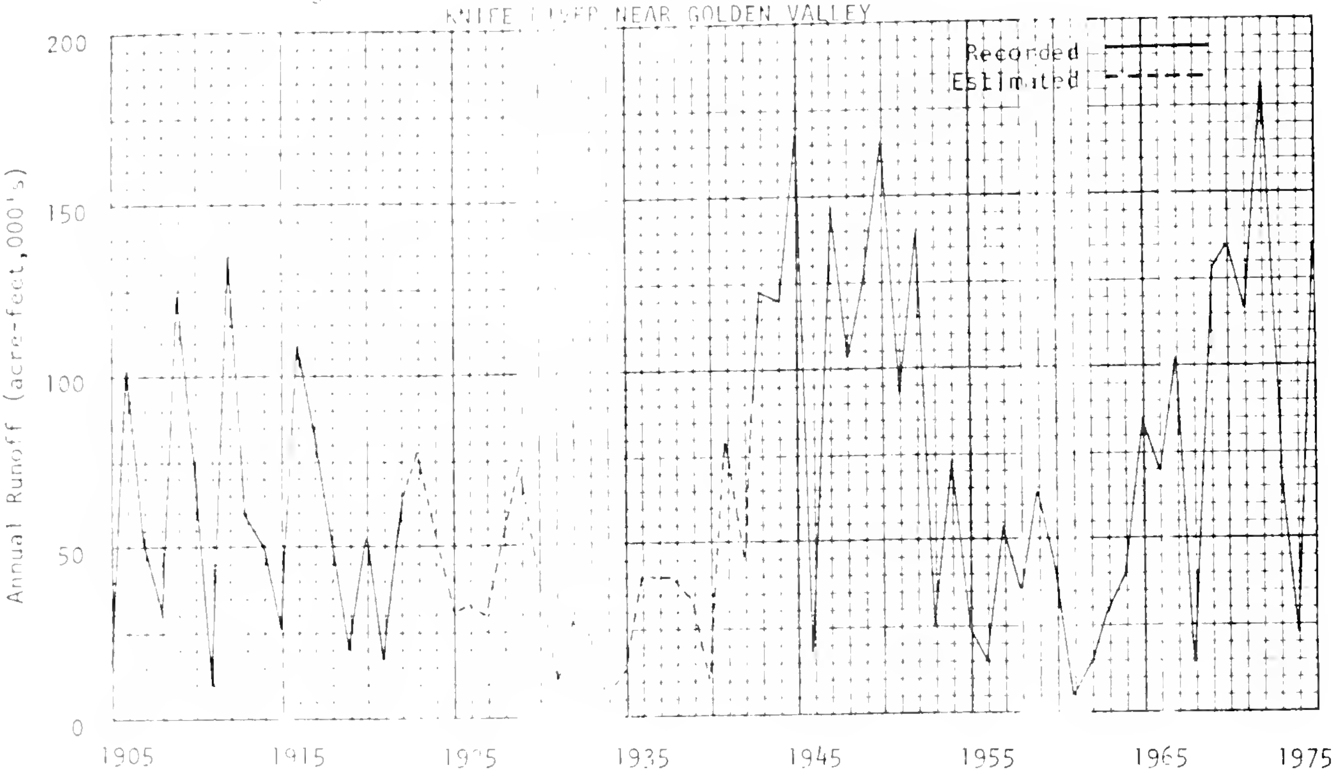


Figure II - 35 - HISTORIC AND GENERATED FLOWS
HEART RIVER NEAR RICHARDTON

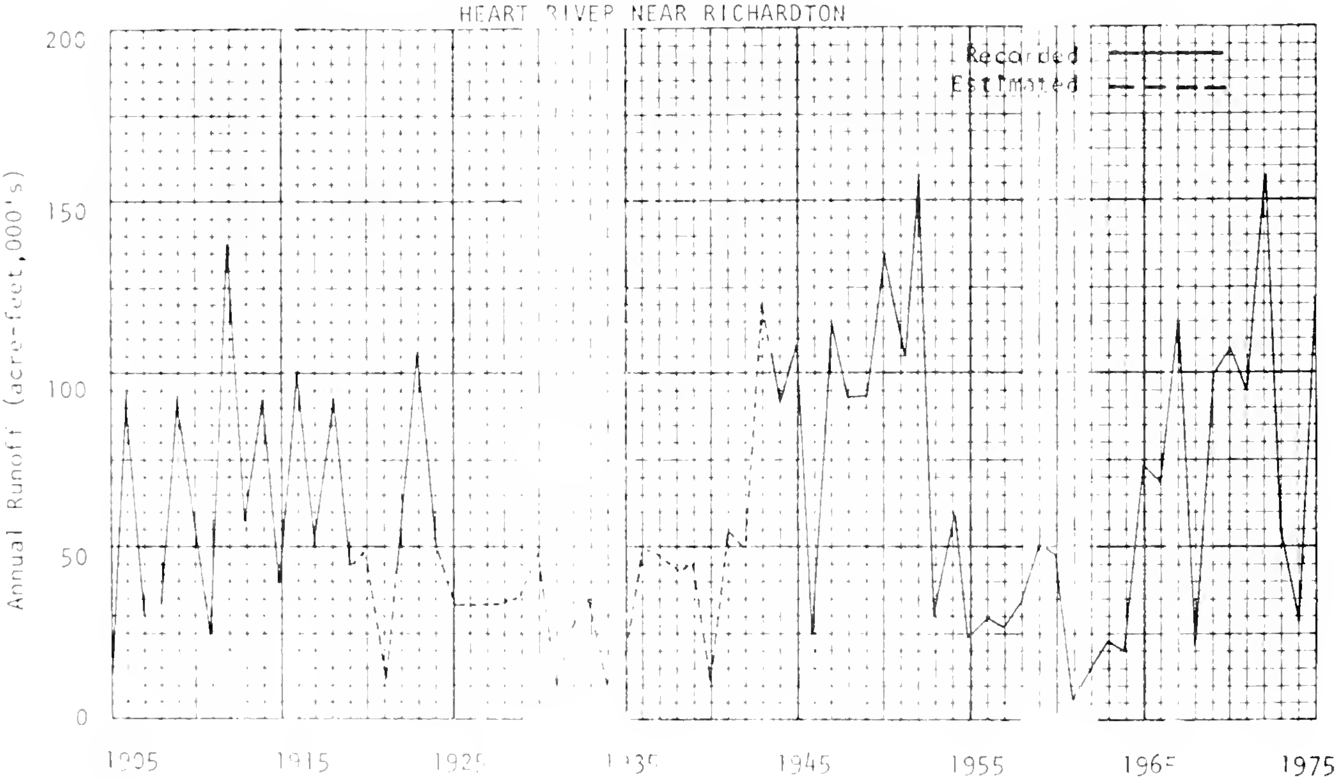


Figure II - 36 HISTORIC AND GENERATED FLOWS
CANNONBALL RIVER AT BREIEN

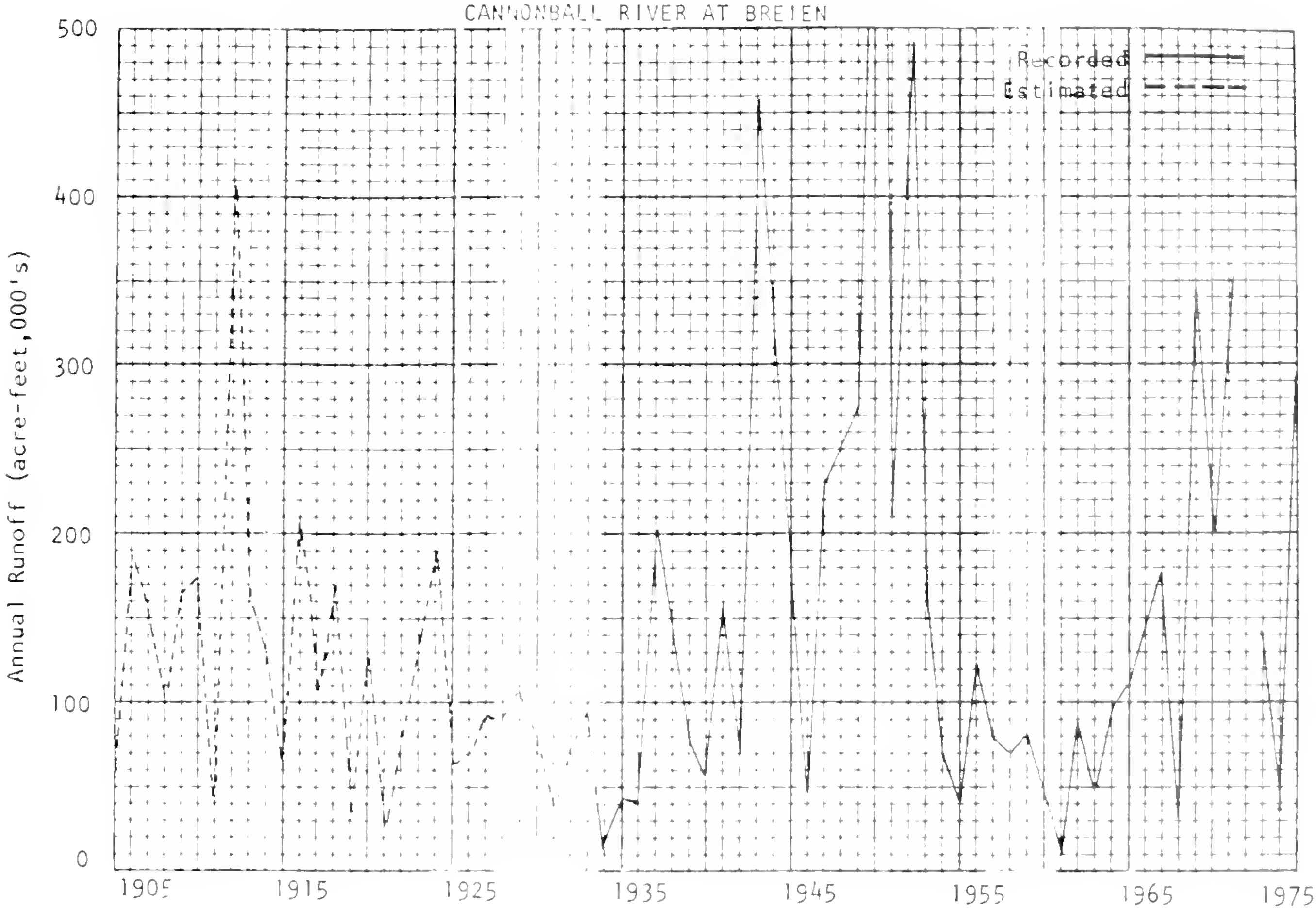


Figure II - 37- HISTORIC AND GENERATED FLOWS
LITTLE MISSOURI RIVER NEAR WATFORD CITY

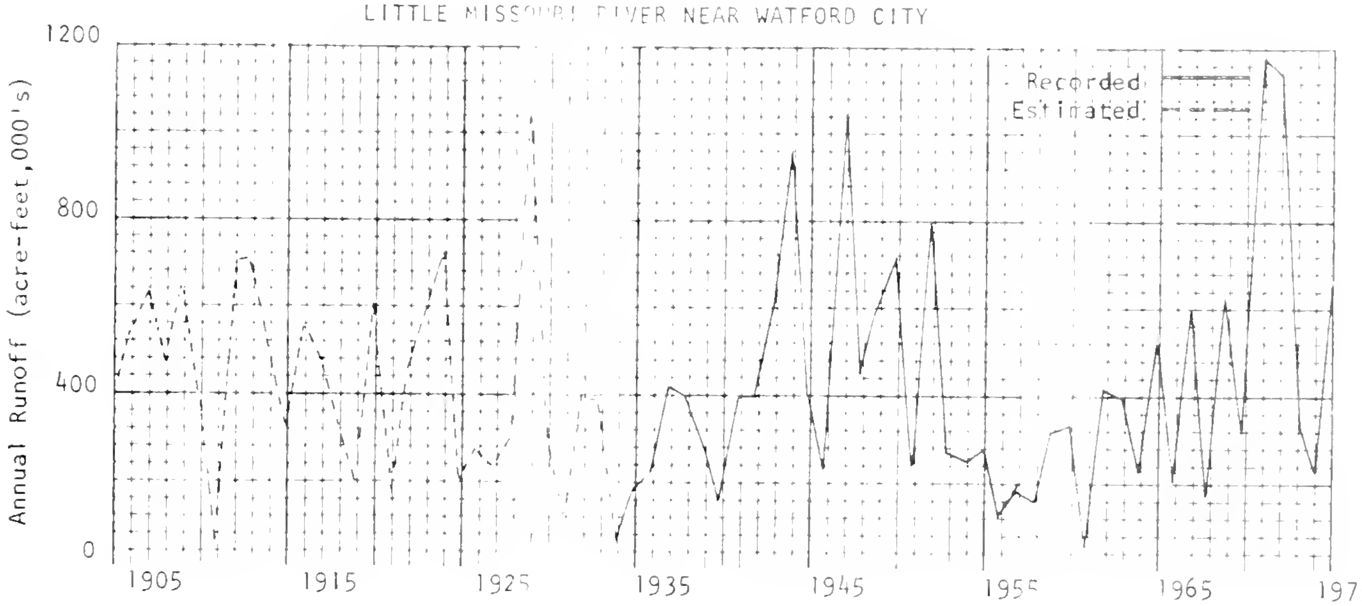


Figure II - 38 - HISTORIC FLOWS
MISSOURI RIVER AT BISMARCK

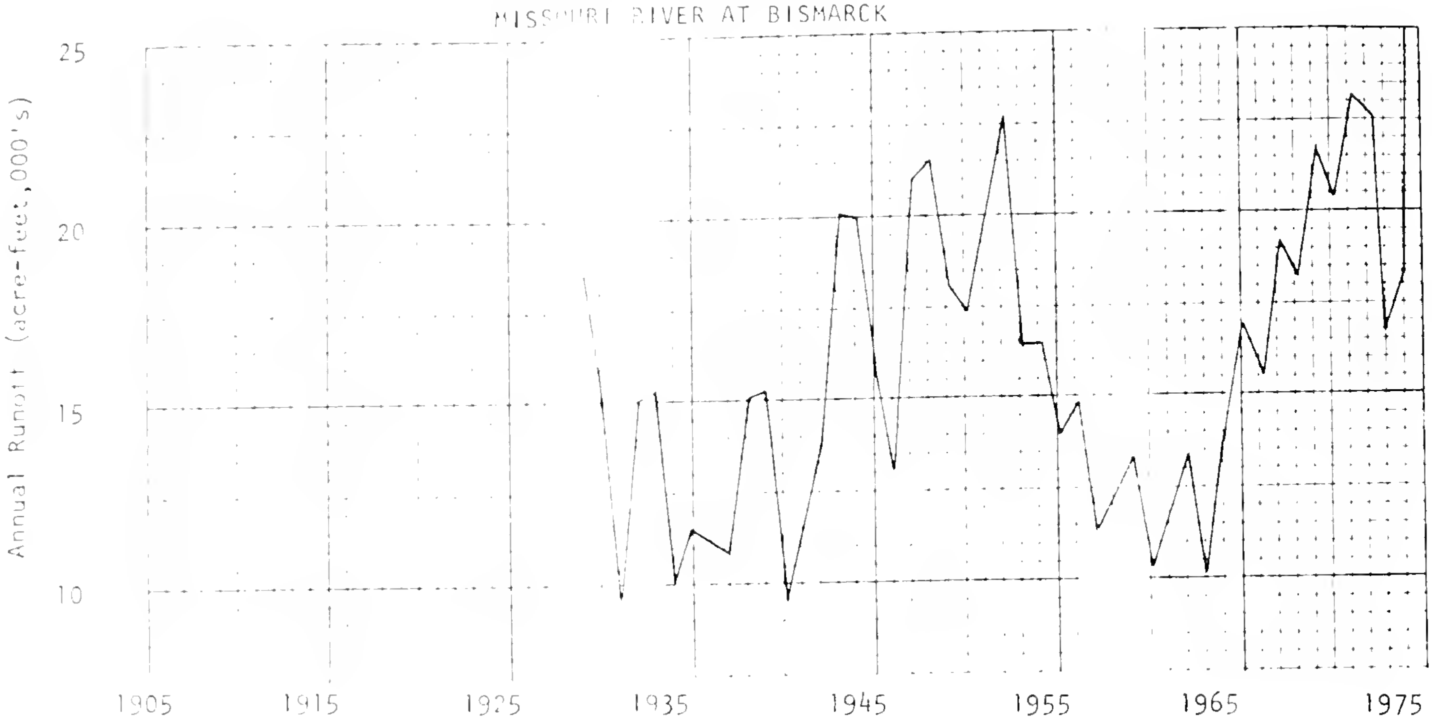


Figure II - 39 HISTORIC FLOWS
MISSOURI RIVER NEAR WILLISTON

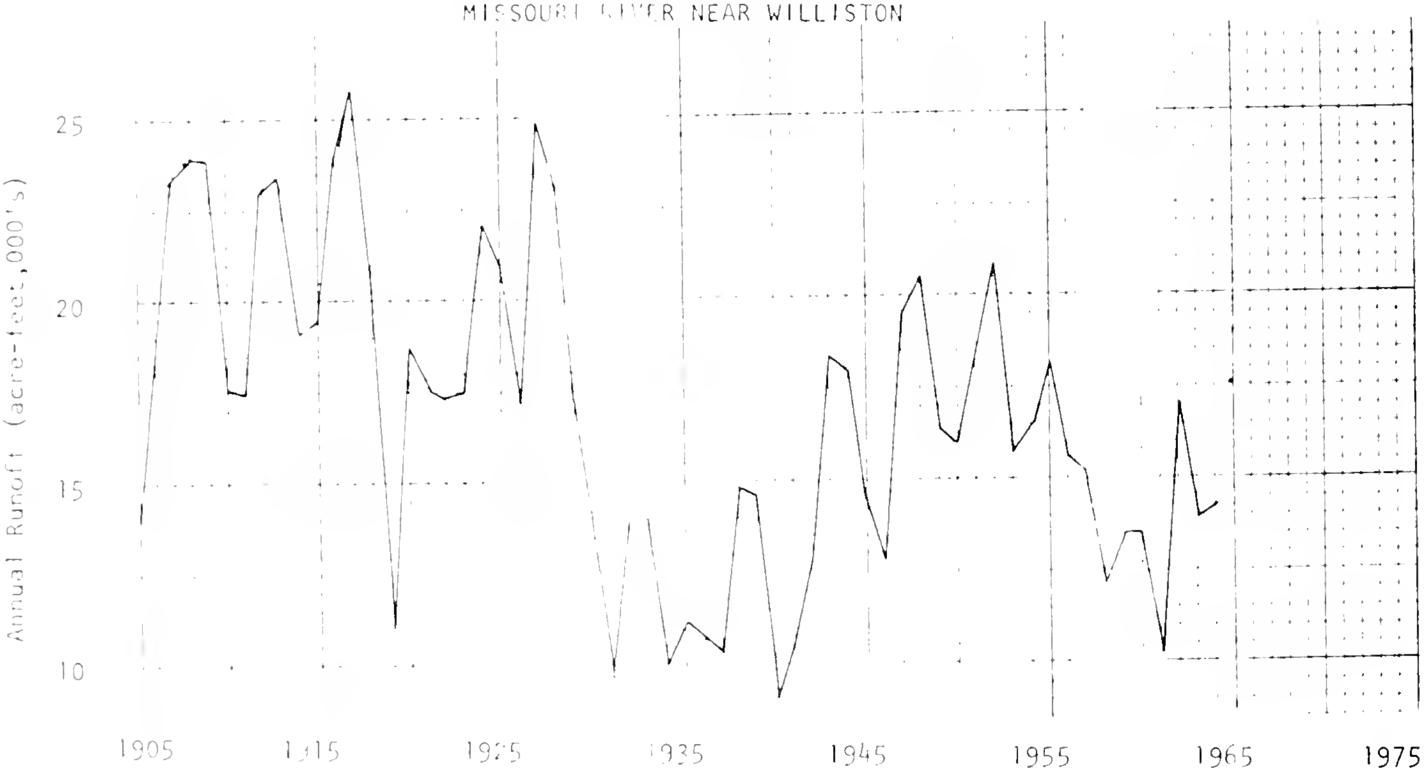


Table II-8. Monthly Runoff Distributions by Percent
North Dakota Tributaries

Gage Station	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Knife River at Manning (6-3391)	0.5	1.6	38.5	24.9	4.7	18.0	6.4	2.0	0.9	1.2	0.8	0.5
Spring Creek at Zap (6-3400)	1.0	3.0	31.0	33.6	6.7	11.1	5.3	2.1	1.6	1.7	1.7	1.2
Elm Creek near Golden Valley (6-3394.9)	0.1	0.7	33.6	40.4	8.7	9.7	3.7	1.5	1.0	0.3	0.2	0.1
Knife River near Golden Valley (6-3395)	0.5	1.5	33.2	28.6	8.1	15.5	5.1	3.7	1.3	1.1	0.8	0.6
Otter Creek near Beulah (6-3402)	0.1	2.3	25.8	33.9	6.6	27.0	1.9	1.1	0.5	0.3	0.3	0.2
Knife River at Hazen (6-3405)	0.7	2.5	29.3	30.7	7.7	14.5	6.3	2.8	1.6	1.6	1.3	1.0
Heart River near South Heart (6-3430)	0.2	2.0	34.6	26.7	9.6	16.9	7.1	1.6	0.4	0.4	0.3	0.2
Green River near Gladstone (6-3450)	0.6	2.1	33.7	31.8	6.8	13.9	5.7	1.9	0.7	1.0	1.0	0.8
Heart River near Richardton (6-3455)	0.4	2.2	33.2	28.1	8.2	15.7	6.8	2.6	0.7	0.8	0.8	0.5
Antelope Creek near Carson (6-3470)	0.5	2.0	32.1	27.6	10.3	16.8	5.6	2.3	0.6	0.6	1.0	0.6
Big Muddy Creek near Almont (6-3475)	0.3	2.0	34.1	36.8	9.1	11.7	3.0	1.4	0.6	0.3	0.4	0.3
Heart River near Mandan (6-3490)	0.2	2.5	31.6	30.7	6.5	15.1	7.0	2.3	0.9	1.3	1.3	0.6
White Fork Cedar Creek near Scranton (6-3516.8)	0.1	1.0	26.4	30.1	10.1	17.0	12.4	1.9	0.4	0.3	0.2	0.1
Cedar Creek near Haynes (6-3520)	0.5	1.3	26.3	31.1	9.9	19.8	6.2	2.4	0.5	0.6	0.7	0.7
Cedar Creek near Pretty Rock (6-3525)	0.3	1.2	27.1	33.4	9.6	16.9	7.0	2.0	0.7	0.7	0.7	0.4
Cannonball River at Regent (6-3500)	0.4	1.4	29.6	22.5	10.3	20.9	8.4	3.2	0.8	1.0	0.9	0.6
Cannonball River near Bentley (6-3510)	0.5	1.8	28.0	28.6	9.9	17.6	7.8	2.2	0.9	0.9	1.1	0.7
Cannonball River at Breien (6-3540)	0.2	1.3	26.7	31.4	10.2	17.0	7.3	2.5	1.2	0.9	0.9	0.4
Little Beaver Creek near Marmarth (6-3350)	0.3	4.9	30.9	25.2	7.4	17.3	5.8	2.3	2.5	2.2	0.6	0.6
Little Missouri River at Marmarth (6-3355)	0.1	4.6	24.3	24.4	11.4	20.9	6.2	2.3	2.2	2.5	0.7	0.4
Little Missouri River at Medora (6-3360)	0.1	2.4	23.6	22.2	12.2	22.4	7.7	3.8	2.3	2.1	0.8	0.4
Little Missouri River near Watford City (6-3370)	0.1	1.9	26.4	22.1	10.2	20.5	8.3	4.3	2.7	2.5	0.8	0.2
North Fork Grand River near Haley (6-3550)	0.2	2.3	29.3	31.6	6.7	15.6	10.7	1.9	0.5	0.4	0.4	0.4
Painted Woods Creed near Wilton (6-3418)	0.0	0.8	35.3	29.2	9.0	10.0	4.2	3.6	2.4	3.5	1.8	0.2

Water Use

A water permit is required in North Dakota for all water uses except domestic and livestock. Dams storing less than 12.5 acre-feet of water are also exempt from a water permit requirement. Water permits were obtained as early as 1894 for irrigation development along the Missouri River. Many of the earlier permits were never used and others were used only for a few years. For this reason, many of these earlier permits have been cancelled.

As of April 1976, water permits for consumptive uses in the planning area totaled 420,000 acre-feet. In addition, 3,145,000 acre-feet have been appropriated for the Garrison Diversion unit. Practically all current water permits in effect were granted after 1950. Only 2 percent of the present water permits was granted by 1936, and only 9 percent of the present permitting was in use in 1950. A summary list of the permits is shown in table II-9. Individual lists of water right permits by river basin can be found in appendix A of the West River Study.

A moratorium exists on water permits in the Cannonball, Cedar and Green Rivers. The Cannonball and Cedar Rivers have adequate flow during the spring snowmelt but do not have adequate flows in the late summer months to support additional irrigation. All water in the Green River has been dedicated to the City of Dickinson for future municipal needs.

Existing Water Projects

Most of the existing water projects in the planning area are small recreation dams or stockponds. Figure II-40 shows existing dams in the planning area whose reservoirs have capacities of 500 acre-feet or more. Table II-10 provides pertinent information for these projects. The following are further descriptions of the larger projects.

Heart Butte Dam

Heart Butte Dam forms Lake Tschida, the largest reservoir totally within the West River Area. It was constructed in 1949 by the U.S. Bureau of Reclamation. Total capacity of the reservoir is 430,000 acre-feet at maximum pool elevation.

Table II-9 - Water Permit Summary 1/
North Dakota Tributaries

Basin	Municipal and Rural Domestic	Industrial	Irrigation	Fish and Wildlife Recreation	Fish and Wildlife Stockwater	Multiple Use	Flood Control
			(acre-feet)				
Knife	2,672 3/	665 3/ 1,643 4/	2,342 3/ 8,626 4/	7,256 2/ 3,807 4/	426 2/ 196 4/		
Heart	13,860 2/ 863 3/ 7,790 4/	1,185 3/ 150 4/	120 3/ 4,761 4/	5,434 2/ 1,789 4/	333 2/ 138 4/	82,785 2/ 31,908 4/	
Cannonball	969 3/ 1,630 4/		148 3/ 8,000 4/	6,600 2/ 1,229 4/	525 2/ 216 4/		
Little Missouri	1,675 3/		582 2/ 13,055 4/	1,500 2/ 412 4/	326 2/ 293 4/		
Grand	1,635 3/ 2,500 4/		2,456 4/		48 2/ 33 4/	26,000 2/ 3,000 4/	
Yellowstone			2,558 3/ 13,185 4/	75 2/ 222 4/	838 4/		
Missouri Direct Tribs. West	105 3/ 17,918 4/	2,702,302 5/ 192,080 6/	122 2/ 54,272 4/	2,645 2/ 881 4/	462 2/ 496 4/		7,650 2/ 400 4/
McLean County	140 4/	15,310 4/	1,700 3/ 9,500 4/	5,260 4/	139 2/ 47 4/	3,145,000 7/	

1. As of April 15, 1976
2. Stored water permit holder maybe required to relinquish this water.
3. Annual use - ground water.
4. Annual use - surface water.
5. Maximum amount that can be circulated; must be returned to stream.
6. Maximum amount that can be consumed.
7. Garrison Diversion Unit total water permit.

The capacity at normal pool elevation is 75,800 acre-feet. The multipurpose reservoir provides for flood control, irrigation and outdoor recreation. Lake Tschida is capable of providing irrigation water to over 10,000 acres and over 3,000 acres are presently irrigated.

Dickinson Dam

Dickinson Dam is an earthfill structure and forms a reservoir designated E. A. Patterson Lake. The reservoir impounds 6,680 acre-feet at normal pool elevation and 24,600 acre-feet at maximum storage. The reservoir is used for municipal supply, flood control and irrigation. The U.S. Bureau of Reclamation constructed the dam in 1950. Because of a projected water shortage for the city of Dickinson, an authorized modification under P.L. 94-224 was enacted March 11, 1976. This authorization is for development to provide a short range municipal and industrial water supply for the city of Dickinson, North Dakota, this by modification of the existing spillway on Dickinson Dam. This will also provide minor attendant benefits to recreation, fish and wildlife. Siltation, expecially bentonite, is a problem in the reservoir.

Bowman-Haley Dam

This earthfill dam was built in 1966 by the U.S. Army Corps of Engineers. The maximum capacity of the reservoir is 93,000 acre-feet. At normal water surface elevation (crest of the spillway) the capacity is 21,950 acre-feet. The reservoir provides a potential municipal water supply for the city of Bowman, outdoor recreation, irrigation and flood control for South Dakota cities along the Grand River.

Nelson Lake

This dam is owned by Minnkota Power Cooperative, Inc. The reservoir provides water for cooling two electric generation complexes, a 250 megawatt unit and a 440 megawatt unit. Located southeast of Center, North Dakota, the reservoir has a present capacity of 10,400 acre-feet. The natural flows in Square Butte Creek are supplemented by 15,000 acre-feet of water diverted from the Missouri River.

Figure II - 40 [illegible]

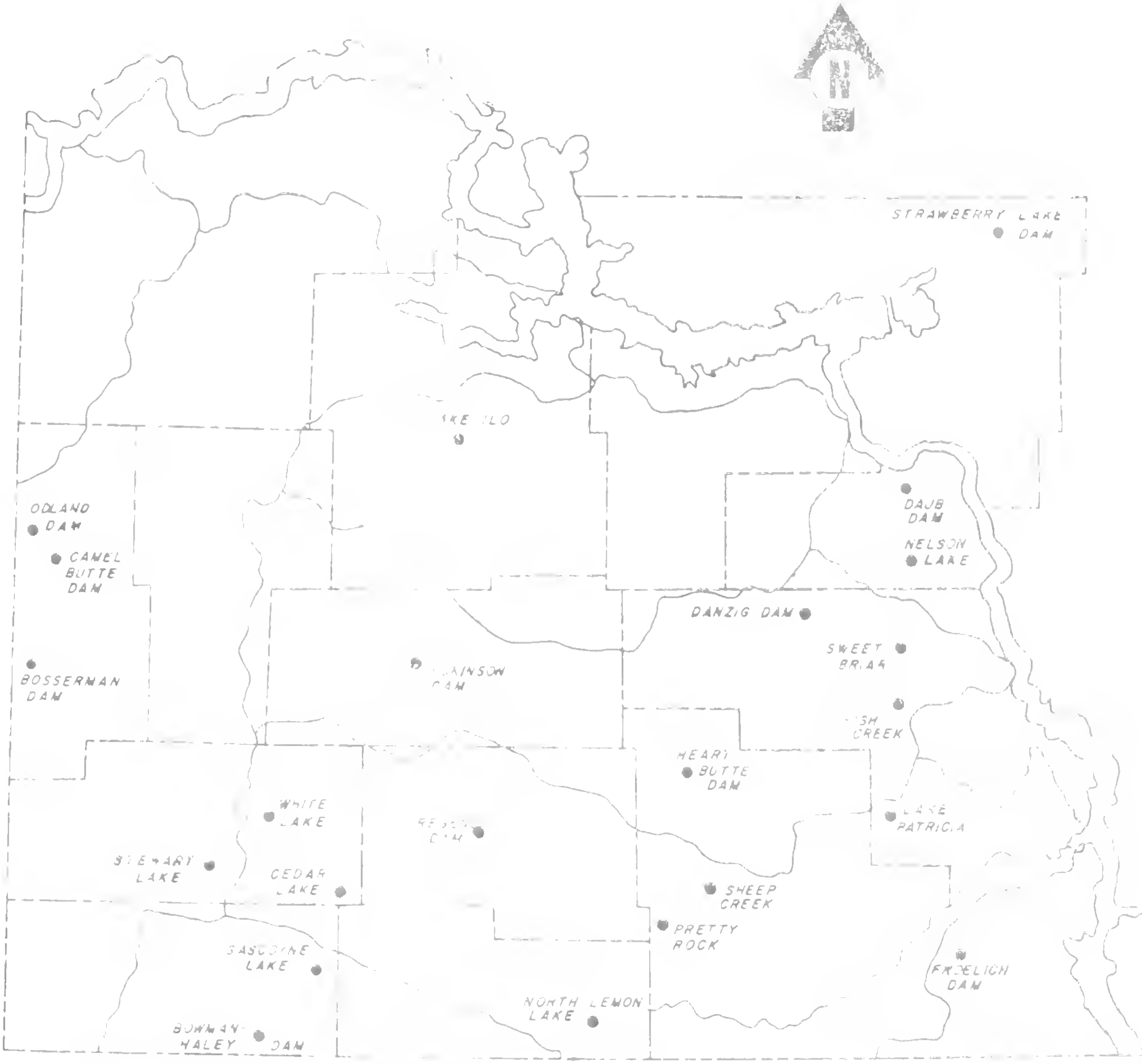

N
STRAWBERRY LAKE DAM
KE ILO
ODLAND DAM
CAMEL BUTTE DAM
DAUB DAM
NELSON LAKE
DANZIG DAM
SWEET BRIAR
BOSSERMAN DAM
AINSOW DAM
SH CREEK
HEART BUTTE DAM
WHITE LAKE
STEWART LAKE
CEDAR LAKE
LAKE PATRICIA
SHEEP CREEK
PRETTY ROCK
SASCOYNE LAKE
FROELICH DAM
NORTH LEMON LAKE
BOWMAN-HALEY DAM

Table II-10 - Existing Projects[1/]
North Dakota Tributaries

Dam/Reservoir	Location (S-T-R)	County	Purpose	Constructing Agency	Year	Drainage Area (sq. mi.)	Total Storage (af)
Lake Ilo	27-145-94	Dunn	FWL/REC	USFWS	1937	167	7,130
Antelope Creek Dam	3-144-87	Mercer	FWL/REC	WPA	1938	54	600
Heart Butte	13-136-89	Grant	Multiple	USBR	1949	1,810	75,800
Sweet Briar Creek Dam	10,11-139-84	Morton	FWL/REC	Highway Dept.	1964	154	3,300
Danzig Dam	36-140-87	Morton	FWL/REC	WPA	1939	40	700
Fish Creek Dam	36-138-84	Morton	FWL/REC	S.C.S.	1971	10	994
Dickinson Dam	8-139-96	Stark	Multiple	USBR	1950	405	6,680
Pretty Rock Dam	16- 32-90	Grant	FWL/REC	USFWS	1938	9	500
Sheep Creek Dam	15-133-89	Grant	FWL/REC	SWC	1970	51	1,375
Regent Dam	8-134-94	Hettinger	FWL/REC	C.C.C.	1934	35	1,167
Lake Patricia Dam	36-135-84	Morton	FWL/REC	Game & Fish Department	1937	17	906
Cedar Lake Dam	35-133-98	Slope	FWL/REC	C.C.C.	1935	205	2,750
White Lake Dam	26-135-100	Slope	FWL/REC	Biological Survey	1937	16	760
North Lemmon Lake	11-129-92	Adams	FWL/REC	City of Lemmon	1908	6	650
Bowman-Haley Dam	24-129-101	Bowman	Multiple	Corps of Eng.	1970	446	21,950
Gascoyne Lake Dam	32-131-99	Bowman	FWL/REC	WPA	1934	78	1,300
Camel Butte Dam	16-140-104	Golden Valley	FWL/REC	State Highway Department	1968	7	760
Odland Dam	8-141-105	Golden Valley	FWL/REC	WPA	1936	95	1,080
Bosserman Dam	3-138-105	Golden Valley	Irrigation	U.S.D.A.-S.C.S.	1971	37	1,033
Stewart Lake Dam	12-133-102	Slope	FWL/REC	Biological Survey	1938	17	802
Nelson Lake Dam	4-141-83	Oliver	Industrial	Minnkota Power Cooperative	1967	139	10,400
Arroda Lake	5-143-83	Oliver	FWL/REC	Highway Dept.	1971	5	732
Froelich Dam	18-131-82	Sioux	FWL/REC	SWC	1961	6	2,200
Strawberry Lake Dam	36-150-80	McLean	FWL/REC	USFWS	1938		1,273

1/ Projects with permanent storages greater than 500 acre-feet

Garrison Dam

This dam is an earthfill structure located in Mercer and McLean Counties. It was completed in 1953 by the Corps of Engineers to form Lake Sakakawea.

Maximum capacity of Lake Sakakawea (elevation 1854 msl)	24,137,023 acre-feet
Storage capacity after reduction of 1.5 million acre-feet to allow for flood control (elevation 1850 msl)	22,635,302 acre-feet
Storage capacity after reduction of 4.3 million acre-feet for multipurpose and flood control zone (elevation 1837.5 msl)	18,347,500 acre-feet
Inactive Storage (elevation 1775 msl)	4,975,541 acre-feet

Based on information from reports issued by the Corps of Engineers, all storage above the 1850 level is to be used exclusively for flood control. The storage between level 1850 and 1837.5 (4.3 million acre-feet) is to be used for both flood control and multiple use. This zone is required to be evacuated each year before the beginning of the March rise. The remaining 18.6 million acre-feet minus 5 million acre-feet for dead storage leaves 13.6 million acre-feet as a multipurpose carryover zone. This zone is to provide for continuity of service during extreme drought periods such as the 1930's.

Ground Water

Ground water in the area south and west of the Missouri River and in McLean County occurs in aquifers within the formations of Paleozoic age; in aquifers within the Dakota, Fox Hills, and Hell Creek Formations of Cretaceous age; in aquifers within the Cannonball-Ludlow, Tongue River, and Sentinel Butte members of the Fort Union Formation of Tertiary age; and in glacial-drift aquifers of Quaternary age. The aquifers are discussed in ascending order.

Aquifers of Paleozoic age, consisting of fine-grained sandstone and porous or cavernous limestone, underlie the area at depths of as much as 14,000 feet below lsd (land surface datum). Data are insufficient to determine the areal extent, thickness (except locally), or degree of interconnection of individual sandstone or limestone aquifers. No data are available to indicate what the pumping rates of wells tapping these aquifers might be.

The Dakota aquifer underlies the entire area at depths exceeding 4,000 feet below lsd. The aquifer is composed of interbedded shale and very fine to fine-grained sandstone. The thickness of the sandstone beds generally ranges from 30 to about 100 feet. Data relating to extent and continuity of individual sandstone beds are not available. Pumping rates in excess of 500 gal/min (gallons per minute) have been obtained in some wells.

The Fox Hills and Hell Creek aquifers underlie the entire area except for a small section in the extreme southwestern corner of the area. The Fox Hills and Hell Creek aquifers are exposed in the southwestern corner of the area and in the eastern parts of Grant, Morton, and Sioux Counties. The depth to the top of the aquifers increases from the outcrop area to more than 1,000 feet below lsd in Dunn and McKenzie Counties. The aquifers are composed of sandstone interbedded with siltstone, claystone, and lignite. Many of the sandstone beds are thin and lenticular and do not extend for more than a few miles. However, at least one, and commonly more than one sandstone bed is present at all locations. The sand-

stone is usually fine to medium grained and frequently contains considerable amounts of interstitial siltstone and claystone. The thickness of the sandstone beds varies from a few feet to about 100 feet. Available data indicate that in some areas the sandstone beds in the Fox Hills Formation are hydraulically connected to those in the overlying Hell Creek Formation. Wells normally flow when tapping these aquifers in topographically low areas. The flow rate generally is less than 50 gal/min, but locally may be as much as 400 gal/min.

The Cannonball-Ludlow, Tongue River, and Sentinel Butte Formations have undergone considerable erosion and therefore the aquifers in these formations underlie a smaller area than the deeper aquifers.

The Cannonball-Ludlow aquifer underlies all of the area except for a small portion in the southwestern part, the eastern three-fourths of Sioux County, and a small area in the southeastern part of Morton County. The Tongue River aquifer is absent in the southwestern one-quarter of Slope County, the southwestern half of Bowman County, most of Sioux County, the southeastern corner of Grant County, and the eastern half of Morton County. The Sentinel Butte aquifer underlies all of Dunn County, much of McKenzie, Stark, Hettinger, Mercer, and McLean Counties, the eastern parts of Billings, Golden Valley, and Slope Counties, and the western parts of Morton and Oliver Counties.

The aquifers of Tertiary age are composed of sandstone interbedded with siltstone, claystone, and fractured lignite. The thickness of these formations ranges from a few feet in the outcrop area to about 1,100 feet in McKenzie County. Most of the sandstone and lignite beds are lenticular and cannot be traced for more than a mile; however, some of the beds can be traced for many miles. Many of the sandstone beds are less than 10 feet thick. The sandstone is chiefly very fine to fine grained and commonly contains considerable amounts of interstitial siltstone and claystone. The lignite beds generally range from 1 to 10 feet in thickness, but thicknesses of as much as 40 feet have been reported.

Wells developed in the sandstone beds generally will yield from 2 to 10 gal/min, but yields of as much as 100 gal/min are obtainable from some of the thicker sandstone beds. Most wells tapping fractured lignite beds will yield from 1 to 5 gal/min; however, in some areas the thicker (10-20 feet) lignite beds will yield as much as 200 gal/min.

Glacial-drift aquifers occur in parts of McKenzie, Dunn, Mercer, Oliver, Morton, Grant, Sioux, McLean, and Stark Counties. These aquifers are glacio-fluvial in origin and are confined for the most part to glacial meltwater channels, diversion channels, and buried valleys.

The glacial-drift aquifers range in thickness from a few feet to about 400 feet and are composed chiefly of sand and gravel. Frequently the sand and gravel deposits are interbedded with or contain lenses of silt and clay. Wells developed in glacial-drift aquifers can be expected to yield from 5 to more than 500 gal/min.

Ground water from aquifers of Paleozoic age and from the Dakota aquifer is used principally for maintaining oil-field pressures. During 1971 approximately 6,500 acre-feet of ground water was pumped into oil fields of the region. Ground water from the Fox Hills and Hell Creek aquifers and from aquifers of Tertiary and Quaternary age is used for rural domestic, livestock, municipal, industrial, and irrigation purposes. The amount of ground water pumped for rural domestic and livestock use in Adams, Bowman, Dunn, Mercer, Oliver, Stark, Hettinger, Grant, Sioux, and McLean Counties is estimated to be about 152,000 acre-feet per year. Estimated pumpage for municipal use is about 2,160 acre-feet per year. Industrial use amounts to about 400 acre-feet per year. Pumpage of ground water from aquifers of Quaternary age for irrigation is estimated to be about 900 acre-feet per year.

Data pertaining to pumpage for the various uses is not available for Billings, Golden Valley, McKenzie, Morton, or Slope Counties.

Surface Water Quality

Water Quality is an essential factor to be considered in comprehensive water resources planning. The following review of surface water quality is taken largely from the Missouri River Basin, North Dakota Water Quality Management Plan, 1974, (North Dakota State Department of Health), the North Dakota 305(b) Report, 1976, (North Dakota State Department of Health), Geological Survey Water Quality Records, and publications of the Environmental Protection Agency.

Yellowstone River

The Yellowstone River flows for only a few miles in North Dakota but it drains a significant portion of the State in McKenzie County bordering on the Little Missouri Basin. Several towns are located in the region and the river itself is an important tributary of the Missouri. The source of the Yellowstone River is in northwestern Wyoming. The river flows in a general northeasterly direction for 871 miles to its confluence with the Missouri River near the town of Buford, North Dakota. Of interest here is the 16 miles of the channel that lie within the State of North Dakota. The Yellowstone River drainage basin includes 478 square miles in the western part of McKenzie County and the northwestern corner of Golden Valley County of North Dakota. Tributaries to the Yellowstone arising in North Dakota include Bennie Pierre Creek, and Charbonneau Creek.

Water quality sampling in 1974-75 indicated that total dissolved solids and phosphates are sometimes in violation of State standards. Other water quality parameters sampled (dissolved oxygen, chlorides, fecal coliform, total coliform, and sodium) were found to be within the Yellowstone's Class I standard.

Little Missouri River

The Little Missouri River enters the State in the extreme southwestern corner in Bowman County and follows a tortuous path northward through Bowman, Slope, Golden Valley, Billings, McKenzie, and Dunn counties where it empties into the Little Missouri Bay of Lake Sakakawea. It passes through a geologically mature

area of well defined drainage consisting of ridges, valleys and buttes. The river passes through the North Dakota Badlands, a high clay area which is the most rugged section in the State. The topographic features associated with this area are caused by the rapid runoff which is common throughout this region of the State and by the clay soil characteristics.

During the spring breakup, runoff water travels through the gullies and ravines and erodes considerable amounts of silt from the stream beds and banks. This load is carried to the mainstream where it is deposited because of a velocity drop which reduces the carrying capacity of the water. At other times of the year most of the tributary streams are dry; however, they are subject to considerable flows of short duration following violent rainstorms which give rise to "flash floods."

The Little Missouri River is a Class II stream and a tributary to the Missouri River. Generally some difficulty was experienced in meeting some of the water quality standards for this stream in calendar year 1975. This stream is basically a sodium sulfate water carrying large amounts of suspended sediments. No hazardous concentrations of heavy metals were observed during the 1974 water year (Geological Survey Water Quality Records, 1974). At low flow periods, the sodium adsorption ratio (SAR) exceeds accepted values suitable for irrigation. This stream is further characterized by high turbidity and iron concentrations.

At Medora, the chloride and the dissolved oxygen levels met the standards of quality set for this stream. The noted violations for phosphates indicated that the river was not meeting the standards for this parameter. There are only two small communities and no industries directly discharging wastes into this segment of the river. Most of the drainage area is agricultural and rangelands with a relatively high percentage classified as "badlands area." Nonpoint sources and natural soil chemicals probably affect the chemical content of these waters.

Fecal coliform violations occurred in two distinct peaks in the months of May and July. These peaks could be partially attributed to the natural runoffs occurring during those months; however, the city of Marmarth, about 125 river miles upstream from the sampling station, was probably responsible. The city had been intermittently discharging sewage with only primary treatment and chlorination. During times of lower stream flow these discharges would have affected the fecal coliform count at the Medora station. The city of Marmarth presently has Federal grants to correct this sewage treatment problem.

Total coliform violations occurred in one distinct peak during the months of June and July. Nonpoint pollution, largely runoff, was probably responsible. Nevertheless, it should be noted that violations for fecal coliform and total coliform were more numerous in 1972 than in 1975.

It is apparent that the Little Missouri River was not consistent in meeting the standards for total dissolved solids. The exceptionally high values during the latter half of the year, however, may be partially attributed to the low flow of the stream. Comparison of TDS for both 1972 and 1975, indicates that violations occurred most frequently during flows of less than 100 cfs.

Knife River

The Knife River originates in western North Dakota and flows easterly to its confluence with the Missouri River. The drainage area at Hazen, North Dakota, is 2,240 mi^2 (5,802 km^2). The Knife River Basin exhibits characteristic features of both unglaciated and glaciated topography. The western and southwestern edge of the basin is unglaciated, but the glaciation boundary is quite indistinct, being marked by stones and boulders of glacial origin.

Badlands topography characterizes the headwaters region of the Knife. The gently undulating uplands of the Great Plains Province has been modified by

glaciation with the addition of glacial materials ranging from zero to 20 feet thick or more. Interstream divides merge smoothly and almost imperceptibly into the maturely dissected slopes of the valleys, while a more youthful topography is characteristic of the valleys themselves. Outcrops of bedrock, the soft tertiary sediments common to the plains are exposed in the western badlands, isolated buttes, and in ridges and valleys of the Knife River and its tributaries.

This stream is basically a sodium sulfate, alkaline-type water. No hazardous concentrations of heavy metals were observed during the 1974 water year. Water quality sampling has indicated that fecal coliform, total coliform, total dissolved solids, and sodium are, at times, in violation of the Class II Standards of the Knife River. Dissolved oxygen, chlorides, and phosphates were found to be within the Class II Standards.

Heart River

The Heart River originates in western North Dakota and flows easterly to its confluence with the Missouri River. The drainage area at Mandan, North Dakota, is 3,310 mi^2 (8,573 km^2), and the basin includes much of Stark County, and parts of Oliver, Morton, Billings, Dunn, Grant, and Hettinger Counties.

Natural drainage is good throughout the subbasin, and most soils generally are free from excessive amounts of alkali. Soils in the upland areas of the basin consist of loam and silt loam, with patches of sandy loam, all of which are well suited for agricultural purposes. Bottom land soils usually range from sandy loam to clay loam. Clay to clay loam predominates in the "breaks" located adjacent to the river. Farmlands in the subbasin are fertile and are capable of producing good grain crops in years of adequate moisture.

Seven communities in the subbasin have municipal water supply systems. The city of Dickinson purchases water stored in Patterson Lake from the U.S. Bureau

of Reclamation. Water pumped from the Missouri River supplies the city of Mandan. Ground water is the source of supply for the remaining five communities with municipal water supply systems. Six communities within the subbasin are without municipal water supply facilities.

Current programs in the subbasin adequately meet quantity demands for rural domestic and livestock water. Virtually all rural domestic requirements are met by ground water developments. Stock water requirements are met by a combination of small dams, dugouts, and ground water. During periods of extreme and extended drought, occasional water shortages may develop. Since ground water is generally available, it may be necessary during such times to develop new and/or deeper wells.

Providing rural domestic water which meets minimum quality standards in the subbasin is a problem. State Health Department standards fix the maximum number of dissolved solids at 500 milligrams per liter for good quality water. Most of the rural domestic water in the subbasin has a higher concentration of dissolved solids. Reduction of high concentrations of sodium, chloride, and sulfates is economically infeasible at this time. Although much of the water does not meet minimum standards, it is safe for human consumption when the human system has been exposed to it for a period of adjustment.

The Heart River is a Class IA stream. Difficulty in meeting some of the water quality standards for calendar year 1975 was experienced at the Mandan station of the Heart River. At this station, the chlorides and the dissolved oxygen parameters met the standards of quality set. Violations for phosphates indicate inconsistency in meeting the standards for this parameter. Those violations may be a continuation of violations which occurred at Gladstone. Fecal coliform violations occurred in one peak during the months of April and May. These two violations may be partially attributed to natural runoff. A July violation may also be attributed to natural runoff, and very possibly may be a continuation of the same violation which occurred at Gladstone.

It is apparent that the Heart River was not meeting the standards for total dissolved solids at its sampling station at Mandan. It should be noted that the violations occurred when there were stream flows of less than 100 cfs. Summer low flows may result in boron being problematical to irrigation development.

Cannonball River

The Cannonball River originates in western North Dakota and flows easterly to its confluence with Oahe Reservoir. The drainage area at Breien, North Dakota, is 4,100 mi^2 (10,619 km^2). The basin lies primarily in the nonglaciated section of the state and exhibits a well-developed drainage pattern and a number of buttes. The basin includes parts of Adams, Hettinger, Bowman, Stark, Grant, Sioux, and Morton Counties.

Ground water is the source of supply for all communities within the subbasin. Nine communities within the subbasin are without municipal systems. Current programs in the subbasin adequately meet quantity demands for rural domestic and livestock water except during periods of extreme and extended drought when local water shortages may develop. Virtually all rural domestic requirements are met by ground water developments. Stock water requirements are met by a combination of small dams, dugouts, and ground water.

Securing "quality" rural domestic and municipal water is a problem in the subbasin. State Health Department standards set the maximum amount of dissolved solids present for "good quality" water at 500 milligrams per liter. None of the six communities with municipal systems is able to meet these standards. Most rural domestic water in the subbasin exceeds this standard. Although much of the water does not meet minimum standards it is safe for human consumption.

The Cannonball River is designated as a Class II river. Water quality sampling in 1974-75 indicated violations of the phosphate, fecal coliform, total coliform, sodium, and total dissolved solids criteria for Class II waters. Dissolved oxygen and chlorides were within the Class II standards. This stream

consists basically of sodium sulfate, slightly alkaline-type water. Summer low flows may result in boron being problematical to irrigation development. SAR values are marginal for irrigation use.

Grand River

The upper reaches of the North Fork of the Grand River drain a triangularly shaped region in Bowman and Adams Counties and, as such, comprises a relatively small portion of the total area of concern of this report. The area lies in the nonglaciated region of the State and is in an area of well-developed drainage patterns similar to the Cannonball and Little Missouri basins in that same general region.

The basin covers 894 square miles within the State of North Dakota. The North Fork of the river has its headwaters in Bowman County near the State boundary and the river flows within two to three miles of the State line until it leaves the State in the southwestern corner of Adams County. The Bowman Haley Dam is located on the Grand River just west of Haley, North Dakota. The characteristics of the area are similar to those of the bordering river basins.

Missouri River

The Missouri River enters North Dakota approximately 25 miles (40 KM) southwest of Williston, North Dakota. The Missouri then flows in a south-southeast direction until it enters South Dakota. Flow regulation of the Missouri in North Dakota is provided by Garrison Dam.

The Missouri River, a Class I stream, generally met the State's Water Quality standards for the calendar year 1975. Water quality data collected at Bismarck indicated that standards for chlorides and dissolved oxygen were met. A minor phosphate violation was noted.

Fecal coliform violations, rather common in 1972, did not occur at all in 1975. Total coliform violations dropped from eight in 1972 to one very minimal violation in 1975.

Minimal violations for total dissolved solids were noted in January and

March. Both these violations were partially attributed to natural runoff.

In general, the waters of the Missouri are of relatively high quality and suitable for all beneficial uses.

Selection of sites suitable for analysis were based on adequacy of data, period of record, and coincidence with streamflow depletion sites. The sites selected for analysis in the North Dakota tributaries were: Little Missouri River near Watford City, Knife River near Hazen, Heart River near Mandan and the Cannonball River at Breien.

Predictive equations were developed using a linear relationship between TDS concentration and flow. Although TDS is only one of numerous important water quality parameters, data on temperature, SO_4, Al, Na, DO, BOD, Cl, NO_4 and PO_4 are not so readily available. In addition these other parameters do not follow the linear relationships between concentration and flow developed for TDS.

The water quality for four locations using the predictive equation and the 1975 depletion level of flow is shown in tables II-11 through II-14.

Table II-11 The Predicted Water Quality Using Predictive Equations and the 1975 Depletion Level, Heart River at Mandan, North Dakota

CALCULATED TDS mgl

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1929	782.87	784.22	786.12	787.39	0.00	745.60	761.00	777.34	741.15	784.05	784.05	783.17
1930	782.71	782.30	785.32	0.00	762.55	692.56	750.26	776.61	765.56	775.30	782.38	782.80
1931	786.11	785.79	786.34	786.13	778.60	780.06	778.60	781.47	777.27	781.57	783.40	783.73
1932	783.77	785.71	786.03	787.39	779.38	765.03	775.14	782.46	770.30	777.23	784.31	786.32
1933	784.34	783.21	785.44	787.40	786.98	715.95	765.74	772.35	773.22	779.38	0.00	784.16
1934	0.00	0.00	0.00	0.00	0.00	771.96	772.85	783.23	775.87	780.19	0.00	0.00
1935	785.46	785.72	0.00	0.00	0.00	776.14	784.15	783.33	770.30	776.29	785.04	0.00
1936	0.00	0.00	0.00	0.00	0.00	777.07	778.71	784.48	784.52	0.00	0.00	0.00
1937	0.00	0.00	0.00	0.00	0.00	774.19	778.71	784.90	720.64	759.97	784.07	784.02
1938	786.05	784.86	785.70	0.00	787.32	762.32	781.30	783.27	767.05	714.04	781.91	783.85
1939	783.19	783.56	785.51	786.65	786.98	715.21	759.19	776.26	768.22	778.92	784.29	783.61
1940	784.44	784.36	785.59	786.89	0.00	677.14	763.53	775.60	712.82	780.24	784.19	786.24
1941	785.14	785.11	785.67	787.07	0.00	749.79	772.95	773.37	685.10	779.95	784.00	783.06
1942	781.65	784.54	786.10	0.00	0.00	765.78	757.15	763.28	749.12	776.66	783.38	783.81
1943	786.97	785.01	787.00	0.00	759.58	585.95	652.78	717.09	705.99	723.72	780.65	782.42
1944	784.66	782.12	785.40	787.10	786.87	773.07	677.40	726.70	694.66	746.08	782.87	782.66
1945	784.25	781.27	785.56	785.75	774.56	650.09	679.75	740.99	767.38	781.06	782.56	783.49
1946	785.19	785.44	786.20	0.00	787.20	755.89	781.09	784.67	780.82	778.63	783.95	783.70
1947	786.65	784.96	786.26	0.00	766.78	732.52	713.74	721.25	714.03	762.93	780.02	783.48
1948	784.92	784.97	785.61	787.07	787.40	643.95	701.45	715.68	767.62	767.77	779.37	783.21
1949	785.84	784.86	786.16	0.00	0.00	712.01	615.70	746.64	761.89	781.47	783.75	783.36
1950	783.48	785.01	786.30	0.00	0.00	780.15	251.35	667.61	759.36	779.84	782.55	783.02
1951	782.74	784.40	785.51	786.10	786.29	671.97	616.82	772.35	776.81	773.41	775.05	777.49
1952	780.02	781.29	785.43	787.19	787.07	786.49	321.35	767.03	772.61	773.08	777.64	775.63
1953	780.80	779.92	786.39	785.88	786.55	779.42	780.41	773.65	737.44	772.45	779.98	780.07
1954	778.11	784.37	780.80	782.54	768.70	772.40	700.06	767.96	778.54	781.50	781.71	781.75
1955	783.38	783.99	785.14	787.01	786.84	779.99	780.26	783.06	778.93	779.71	782.21	785.22
1956	783.13	782.85	783.13	786.44	785.56	719.56	761.00	774.37	778.36	775.80	782.92	784.06
1957	782.34	779.75	784.91	786.69	787.30	780.44	780.21	781.83	775.54	768.06	785.16	784.56
1958	782.84	782.21	785.[illegible]	786.40	786.95	785.63	761.81	781.58	777.17	781.33	783.64	783.38
1959	782.98	784.31	786.69	0.00	0.00	698.91	750.32	782.35	782.54	784.14	784.40	784.02
1960	782.52	784.94	785.20	786.27	786.94	733.99	761.00	781.42	766.70	751.54	784.30	783.13
1961	784.40	784.95	785.61	786.57	786.95	784.23	784.86	785.86	785.79	786.49	786.35	785.05
1962	786.16	786.26	786.95	0.00	0.00	776.71	782.19	774.19	769.54	778.35	784.93	784.12
1963	785.97	784.98	785.74	787.30	0.00	782.03	782.25	783.19	773.52	778.36	775.21	782.33
1964	782.99	783.92	785.75	787.01	786.81	786.57	781.26	782.38	752.77	733.79	781.60	783.27
1965	782.74	784.94	786.77	0.00	0.00	0.00	728.93	742.93	739.30	781.14	779.94	778.14
1966	780.54	784.72	784.43	786.83	0.00	647.16	764.75	779.58	702.79	734.30	776.95	781.04
1967	782.35	784.03	785.12	785.68	785.96	619.41	719.91	635.84	772.10	780.57	779.02	780.41
1968	783.21	784.37	785.22	787.34	786.87	768.57	781.18	784.55	776.22	783.31	778.55	784.38
1969	785.46	786.03	786.48	787.17	787.27	782.14	429.13	771.20	775.22	683.85	778.17	778.65
1970	783.48	784.05	784.83	786.05	786.06	785.67	779.36	678.00	739.94	765.26	773.46	778.50
1971	782.64	784.45	785.49	786.73	785.27	643.12	686.94	760.89	737.01	769.77	779.59	779.01
1972	782.31	785.01	784.75	785.39	786.43	548.49	714.97	689.86	709.53	765.53	772.49	776.97
1973	783.91	783.26	784.28	782.92	765.41	665.59	772.22	775.41	778.87	780.74	780.24	782.45
1974	784.89	784.68	784.64	783.54	781.26	775.44	779.18	782.36	781.99	782.37	782.87	783.95
1975	784.65	784.82	785.27	786.66	787.13	785.37	601.40	614.74	749.60	770.56	776.37	782.34
0	733.58	734.09	718.64	535.37	572.59	720.17	717.45	753.74	758.54	753.40	731.47	732.48
used	692											772

Table II-12 The Predicted Water Quality Using Predictive Equations and the 1975 Depletion Level, Little Missouri at Watford City, North Dakota

CALCULATED TDS mgl

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1929	1539.60	1577.08	1623.62	1634.73	1637.44	500.00	500.00	500.00	500.00	1322.43	1527.32	1562.61
1930	1310.07	1570.85	1609.05	1621.94	500.00	500.00	1477.54	1575.24	500.00	1451.14	1431.87	857.49
1931	1587.33	1606.13	1607.02	1607.41	1382.21	1520.55	1508.66	0.00	1385.18	1262.32	894.44	1319.84
1932	1489.88	1552.18	1604.94	1621.94	1473.51	500.00	500.06	595.27	500.00	681.32	1494.12	1558.45
1933	1444.15	1435.58	1617.39	1632.21	1552.36	500.00	523.04	500.03	1258.61	1482.27	0.00	0.00
1934	0.00	1626.88	1575.87	1232.71	1544.75	0.00	1579.21	0.00	1264.83	1548.67	0.00	0.00
1935	0.00	1637.48	1626.88	0.00	0.00	1575.75	0.00	1502.67	864.36	500.00	1552.01	0.00
1936	1633.20	1636.65	1634.80	1635.74	0.00	500.00	519.57	1625.56	0.00	0.00	0.00	0.00
1937	0.00	1637.13	1628.12	0.00	0.00	908.01	692.98	1584.85	500.00	500.00	500.00	1395.99
1938	1535.87	1625.77	1577.07	0.00	1620.30	700.05	1324.35	1557.42	500.00	500.00	1476.27	1361.95
1939	1570.52	1626.17	1626.25	1623.24	0.00	500.00	1235.80	1617.62	829.91	686.71	1539.15	1638.77
1940	1576.15	1575.70	1577.15	1635.63	0.00	1195.40	755.07	1204.90	1239.72	1274.77	989.69	1260.29
1941	1341.02	1605.45	1629.45	1636.15	1627.54	1050.36	894.26	1465.73	500.00	1341.79	1198.22	500.00
1942	1068.58	1560.36	1565.98	1636.05	0.00	500.00	618.28	503.00	500.00	1516.09	1528.36	1480.03
1943	1539.15	1595.34	1628.31	1627.50	500.00	500.00	500.00	1494.20	500.00	644.18	1171.87	1505.14
1944	1610.77	1572.37	1635.45	1633.62	1638.31	0.00	500.00	552.35	500.00	575.95	1381.24	1518.83
1945	1554.17	1455.42	1633.60	0.00	1449.86	500.00	977.44	1536.32	1132.65	1571.91	1581.48	1536.68
1946	1528.19	1526.57	1577.67	1233.33	1314.99	1104.93	1377.03	1398.71	500.00	1101.51	1621.32	1484.18
1947	556.72	1133.66	1462.35	1549.73	500.00	500.00	500.00	1367.17	500.00	500.00	900.46	1607.64
1948	1550.95	1605.86	1620.11	1635.78	1332.21	500.00	500.00	1172.53	524.06	500.00	1213.99	1627.56
1949	1618.04	1561.03	1625.15	1635.94	1636.24	500.00	500.00	1361.77	1624.43	1639.97	0.00	0.00
1950	1529.64	1595.94	1628.05	0.00	0.00	500.00	500.00	500.00	1317.95	1545.14	1399.87	1483.76
1951	1546.66	1611.54	1639.80	0.00	1311.04	500.00	984.31	1566.37	1572.14	1487.25	1460.30	1028.51
1952	1479.80	1590.99	1621.94	1633.33	1631.09	848.54	500.00	1297.66	1543.22	1316.89	1562.59	1609.09
1953	1620.11	1617.75	1625.34	1640.36	1632.04	1033.55	1452.85	500.00	500.00	1447.41	1308.82	1399.73
1954	1518.84	1578.11	1623.16	1639.82	1047.31	1508.52	500.00	1621.56	867.88	1524.60	992.59	1011.70
1955	1605.39	1612.56	1631.05	1637.60	0.00	694.70	500.00	770.81	500.00	1174.34	1594.96	0.00
1956	1633.89	1633.50	0.00	1640.55	0.00	949.51	1386.24	1617.83	1594.76	1053.16	1093.64	1568.42
1957	1622.52	1624.66	1632.40	1634.81	1501.32	1017.74	1235.30	1612.02	500.00	1154.17	1513.00	1223.77
1958	1540.38	1579.70	1606.81	1614.72	1632.19	565.27	1381.47	1581.12	818.83	623.83	0.00	0.00
1959	1630.15	1627.58	1637.25	0.00	0.00	500.00	898.61	1576.95	1519.85	1543.07	0.00	1443.72
1960	1539.81	1610.07	1619.10	1637.47	1633.70	500.00	1142.87	1585.46	537.13	1554.48	1526.07	1621.13
1961	1634.03	1628.87	1639.51	0.00	1639.31	1291.32	1569.46	1530.26	0.00	1569.21	1505.74	1422.55
1962	1585.94	1618.89	1636.46	1640.59	1625.65	471.05	1353.66	500.00	500.00	500.00	1311.31	1583.99
1963	1493.33	1555.17	1623.12	1639.45	1104.79	500.00	500.00	538.06	500.00	1242.40	1434.98	1348.06
1964	1528.34	1610.07	1633.35	1640.62	0.00	0.00	1414.04	1291.90	500.00	500.00	1293.47	1398.27
1965	1539.36	1615.21	1634.60	1634.06	1633.70	1576.16	500.00	500.00	500.00	500.00	1470.26	1369.85
1966	1575.59	1595.96	1618.26	1636.43	1639.45	500.00	1393.50	1534.83	1438.72	896.50	1471.92	1633.16
1967	1610.36	1625.44	1636.55	0.00	1562.32	500.00	500.00	500.00	500.00	1290.99	1616.96	1371.51
1968	1492.08	1590.77	1629.37	1636.52	1447.58	500.00	1481.69	1598.12	1278.73	1451.35	1205.28	1498.50
1969	1556.04	1595.28	1627.25	1638.08	0.00	500.00	500.00	500.00	832.61	500.00	1362.77	1630.47
1970	1612.43	1611.77	1626.88	1635.84	1625.74	1458.10	500.00	500.00	500.00	1359.01	1417.76	1563.86
1971	1554.59	1570.02	1618.02	1636.52	954.14	500.00	500.00	746.74	500.00	778.01	1581.27	953.39
1972	500.00	1156.20	1556.41	1554.42	1583.92	500.00	504.05	500.00	500.00	1008.17	916.81	1510.39
1973	1519.14	1558.26	1630.90	1611.71	456.24	500.00	1006.60	1148.63	500.00	1305.67	1581.02	1203.62
1974	1493.85	1555.00	1601.56	1629.73	1483.39	1111.74	804.18	500.00	702.24	1420.17	1491.77	1619.14
1975	1622.95	1577.66	1633.29	1629.53	1637.94	592.34	500.00	500.00	500.00	753.86	1520.35	1591.06
0	1404.04	1574.07	1587.27	1312.94	1040.19	718.32	863.11	1069.07	768.01	1066.18	1182.88	1138.15

Table II-13 The Predicted Water Quality Using Predictive Equations and the ~~1975 Depletion Level~~, Knife River at Hazen, North Dakota

CALCULATED TDS mgl

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	1111.95	1111.25	1114.85	1115.56	829.27	778.60	1056.40	1093.54	1039.70	0.00	0.00	1112.20
1931	1109.99	1105.91	1113.81	1113.91	1114.26	1107.15	1109.09	1115.41	1102.05	1113.33	1109.10	1073.68
1932	1106.38	1112.33	1114.87	1115.54	1109.81	1025.86	1077.82	1098.96	1041.46	0.00	0.00	1113.28
1933	1108.90	1107.77	1113.33	1114.52	1053.31	716.50	1065.91	1081.51	1111.78	0.00	0.00	0.00
1934	0.00	1114.35	0.00	0.00	1115.13	0.00	0.00	.00	1109.04	0.00	0.00	0.00
1935	1114.27	0.00	0.00	0.00	0.00	1108.66	1115.13	1100.58	1059.93	976.55	1113.30	0.00
1936	1114.27	0.00	0.00	0.00	0.00	540.83	1054.16	1112.33	0.00	0.00	0.00	0.00
1937	0.00	1114.35	0.00	0.00	0.00	1020.83	1001.01	1104.50	615.1[illegible]	974.32	970.09	1113.62
1938	1109.32	1107.52	1114.45	1114.64	0.00	955.57	1100.53	1090.91	1060.32	790.38	1060.60	1107.36
1939	1104.55	1107.02	1111.49	1112.70	1113.72	615.11	1076.70	1097.79	1097.46	1096.77	1113.69	1110.83
1940	1108.67	1108.14	1109.25	1114.21	1114.69	0.00	1096.34	1090.23	0.00	1084.47	0.00	1115.56
1941	1107.22	1110.51	1112.92	1114.17	0.0[illegible]	[illegible]	[illegible]	1089.40	837.70	0.00	0.00	1099.58
1942	1058.10	1108.08	1111.55	1112.94	1114.25	978.87	988.37	1087.94	956.94	1102.82	1109.50	1110.32
1943	1106.99	1108.25	1114.28	1114.37	1012.97	300.00	858.75	1088.72	970.70	1066.96	1096.01	1102.88
1944	1102.02	1096.67	1103.83	1110.88	1111.21	1052.88	688.35	1077.65	776.02	1046.48	1111.40	1106.35
1945	1102.74	1095.10	1110.43	1110.09	1086.49	338.75	1063.56	1096.33	1020.04	1107.68	1112.12	1109.55
1946	1105.82	1105.90	1111.84	1111.09	1082.46	510.73	1104.17	1111.66	1079.62	1073.95	0.00	1111.83
1947	1102.35	1105.53	1110.77	1081.51	1025.62	587.18	861.72	1102.37	836.72	1075.29	1096.13	1107.53
1948	1103.30	1104.84	1107.24	1109.81	1111.16	638.97	856.74	1054.38	1022.39	1100.86	1111.84	1111.83
1949	1106.55	1104.50	1109.53	1112.29	1114.86	1074.36	409.15	1093.30	1091.36	1108.35	1107.43	1109.54
1950	1103.25	1104.84	1109.42	1112.54	1115.64	581.50	300.00	562.18	1084.37	1101.25	1105.24	1102.21
1951	1059.22	1103.72	1105.84	1106.40	1110.49	881.59	534.46	1072.39	1078.05	1100.88	1084.15	1091.41
1952	1058.94	1103.49	1105.23	1110.21	1106.91	1110.78	300.00	1078.15	1089.41	1089.50	1104.57	1104.51
1953	1103.30	1102.87	1108.00	1108.88	1107.74	1060.09	1095.83	1055.55	598.76	1100.58	1110.61	1111.72
1954	1106.49	1106.63	1107.46	1110.15	989.04	1070.17	888.07	1097.56	1080.85	1115.46	1049.41	1077.60
1955	1104.09	1105.12	1105.56	1109.48	1108.64	1017.64	1040.28	1105.06	1104.06	1108.80	0.00	1112.68
1956	1109.86	1110.34	1112.14	1114.15	1115.52	800.75	1065.07	1099.52	1083.81	1105.89	1111.12	1111.55
1957	1109.01	1107.86	1109.71	1112.60	1100.64	578.37	1089.60	1103.21	1045.60	1090.23	0.00	1114.00
1958	1108.39	1108.70	1107.80	1110.65	1112.72	1002.20	1047.11	1112.39	1115.20	1053.81	0.00	0.00
1959	1111.07	1108.70	1112.48	1115.01	0.00	738.04	1060.93	1108.02	1109.43	0.00	0.00	1111.39
1960	1104.25	1105.75	1109.87	1113.45	1114.46	642.32	1067.86	1107.02	1099.53	1114.23	1112.68	1113.70
1961	1111.00	1110.37	1112.38	1115.18	1107.18	1064.52	1109.65	1108.98	0.00	0.00	0.00	0.00
1962	1112.07	1111.78	1114.83	.00	0.00	1064.19	1097.50	1011.47	909.27	1012.30	1100.66	1110.44
1963	1107.83	1108.02	1109.09	1114.26	1113.30	1081.75	1087.83	1081.40	1041.30	1091.80	1096.63	1111.11
1964	1109.81	1107.97	1111.97	1114.41	1113.67	0.00	1096.06	1090.40	988.10	1049.62	0.00	1099.58
1965	1109.12	1108.81	1111.25	1114.38	1113.58	0.00	780.27	551.78	1014.94	1046.87	1105.19	1105.74
1966	1105.26	1106.40	1108.81	1113.73	1115.10	800.02	1096.28	1100.30	866.70	1025.06	1083.48	1111.33
1967	1107.09	1110.47	1110.61	1111.34	1112.74	434.56	904.23	870.38	1048.79	1109.72	1110.45	1105.14
1968	1103.86	1104.28	1105.73	1113.47	1113.05	583.01	1094.49	1101.42	1094.27	1115.07	1093.44	1109.15
1969	1107.27	1105.12	1109.20	1113.67	1112.47	1021.16	331.30	1087.05	1092.43	943.88	1086.62	1107.69
1970	1104.59	1105.23	1105.23	1110.77	1109.76	1103.17	914.13	592.74	998.67	1071.66	1091.59	1104.73
1971	1097.54	1098.74	1104.61	1109.25	1070.43	455.33	923.60	1079.44	879.34	1094.98	1113.41	1101.82
1972	1084.00	1110.24	1110.16	1107.74	1106.63	300.00	1032.12	592.45	968.52	1092.07	1084.32	1104.17
1973	1092.79	1094.71	1105.42	1093.42	1063.89	820.70	1083.03	1094.37	1095.48	1115.44	1114.59	1112.45
1974	1107.79	1105.60	1107.81	1065.79	1044.73	992.94	1054.12	1072.03	1094.84	1114.59	1113.37	1113.70
1975	1110.58	1108.03	1108.33	1111.02	1112.81	1100.01	491.74	891.26	1025.43	1079.97	1100.71	1107.12
0	1057.65	1058.63	1013.27	989.30	924.79	810.25	918.82	1038.35	950.71	883.87	762.68	962.48
Historical	1057	1067	[illegible]	[illegible]	[illegible]	737	772	[illegible]	[illegible]	730	869	978

Table II-14 The Predicted Water Quality Using Predictive Equations and the 1975 Depletion Level
Cannonball River at Breien, North Dakota

CALCULATED [illegible] mg/l STA [illegible]

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1929	[illegible]	1404.55	1408.09	1409.11	1410.60	800.00	1193.09	1382.48	1123.05	0.00	0.00	1412.29
1930	1400.55	1404.90	[illegible]	1410.14	1181.27	948.11	1284.81	[illegible]	1341.11	0.00	0.00	1412.29
1931	[illegible]	[illegible]	[illegible]	1405.03	1338.12	1403.79	1392.87	[illegible]	1335.17	1403.45	0.00	1411.27
1932	1413.78	[illegible]	[illegible]	1412.17	1293.35	1081.	[illegible]	[illegible]	927.36	1373.99	0.00	0.00
1933	1400.72	[illegible]	1411.15	1411.15	[illegible]	940.02	1319.49	1354.95	0.00	0.00	0.00	0.00
1934	[illegible]	[illegible]	[illegible]	0.00	[illegible]	0.00	1400.17	[illegible]	0.00	0.00	0.00	0.00
1935	[illegible]	[illegible]	0.00	0.00	[illegible]	[illegible]	0.00	[illegible]	[illegible]	1234.26	1401.98	0.00
1936	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00
1937	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]	1241.00	0.00	[illegible]	1240.13	[illegible]	1363.37
1938	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1110.85	[illegible]	[illegible]	1381.71
1939	[illegible]	[illegible]	1405.05	1411.15	0.00	[illegible]	[illegible]	[illegible]	1392.44	1328.03	0.00	1411.27
1940	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	1402.44	1369.36	1410.25
1941	[illegible]	[illegible]	[illegible]	0.00	0.00	879.86	1336.77	[illegible]	810.00	1399.36	0.00	1388.65
1942	[illegible]	1402.91	[illegible]	1412.17	1411.62	[illegible]	[illegible]	[illegible]	1313.65	1401.42	1410.13	1402.10
1943	[illegible]	[illegible]	[illegible]	1412.17	1235.25	[illegible]	[illegible]	1344.77	933.47	1105.84	1394.84	1399.64
1944	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	800.00	1151.70	1395.88	1397.00
1945	[illegible]	[illegible]	1364.94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1392.24	1400.96	1401.08
1946	[illegible]	[illegible]	[illegible]	1411.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1317.84	0.00	1404.14
1947	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	871.73	[illegible]	[illegible]	853.97	1274.01	1411.15	1410.25
1948	[illegible]	[illegible]	[illegible]	1411.59	[illegible]	[illegible]	[illegible]	[illegible]	1391.11	1347.40	1379.55	1410.25
1949	[illegible]	[illegible]	[illegible]	1411.15	0.00	800.00	800.00	[illegible]	1345.25	0.00	1389.75	1407.20
1950	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1360.65	1305.15	1377.54
1951	[illegible]	[illegible]	1364.84	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1366.76	1302.09	1320.56
1952	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1298.47	[illegible]	1370.50
1953	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	800.00	1315.80	1368.34	1402.10
1954	[illegible]	1374.76	[illegible]	[illegible]	[illegible]	[illegible]	1110.54	[illegible]	[illegible]	1403.45	[illegible]	1333.81
1955	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1382.61	1389.87
1956	[illegible]	[illegible]	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	[illegible]	1372.88	1376.50	1389.87
1957	[illegible]	1390.68	[illegible]	[illegible]	1412.64	[illegible]	[illegible]	1336.61	[illegible]	1262.80	1386.69	1403.12
1958	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1161.78	1378.99	0.00	0.00
1959	0.00	1411.07	[illegible]	0.00	0.00	800.00	1371.71	1394.71	1410.48	0.00	0.00	0.00
1960	1412.78	[illegible]	1411.15	0.00	0.00	1065.44	1355.15	1386.56	[illegible]	1410.59	1412.17	0.00
1961	0.00	0.00	0.00	0.00	[illegible]	1409.87	1410.19	0.00	1409.46	0.00	1411.15	1398.02
1962	[illegible]	[illegible]	0.00	0.00	0.00	1268.21	1381.45	[illegible]	1045.59	1327.01	1366.30	1400.06
1963	1408.70	1406.90	1410.13	1412.17	1412.64	1251.90	[illegible]	[illegible]	[illegible]	1360.65	1407.07	1412.29
1964	1410.74	1410.05	1412.17	0.00	0.00	[illegible]	[illegible]	1345.79	800.00	1324.97	0.00	0.00
1965	1412.78	[illegible]	1412.17	0.00	0.00	0.00	[illegible]	[illegible]	1157.71	1367.78	1393.82	1397.00
1966	1401.57	[illegible]	1405.03	1412.17	0.00	800.00	[illegible]	1337.63	1200.51	1033.59	1367.32	1404.14
1967	1402.55	1400.98	1401.98	[illegible]	1361.69	[illegible]	1251.19	800.00	[illegible]	1381.03	1412.17	1409.21
1968	[illegible]	1405.57	1406.05	1411.15	1412.64	1297.69	1355.15	[illegible]	[illegible]	1407.53	1393.82	1406.18
1969	1411.76	1405.97	1409.11	1411.15	0.00	814.65	800.00	1331.52	1322.82	800.00	1345.92	1405.16
1970	1403.61	[illegible]	1359.94	[illegible]	1406.52	1386.44	[illegible]	800.00	1147.51	[illegible]	1336.75	1400.06
1971	1403.40	1385.79	1367.90	1403.61	1390.43	800.00	800.00	1348.55	947.44	1188.29	1363.95	1405.06
1972	1358.25	1384.54	1362.44	[illegible]	[illegible]	800.00	1091.77	800.00	985.08	1264.65	1308.26	1377.68
1973	1366.25	1374.17	[illegible]	[illegible]	[illegible]	413.74	[illegible]	1324.49	[illegible]	1340.24	1411.95	1392.76
1974	1385.37	1400.60	1359.90	[illegible]	1340.64	[illegible]	1328.16	1367.03	1383.21	1410.18	0.00	0.00
1975	1413.01	1407.07	1407.73	1411.05	1412.53	1385.84	800.00	800.00	1202.28	1296.96	1354.86	1398.48
M	[illegible]	1241.55	1156.18	[illegible]	[illegible]	[illegible]	1166.39	1132.79	[illegible]	1077.82	968.80	[illegible]

Water Quality Ground Water[10]

Ground water quality in the planning area varies according to the depth, location, and geologic formation. Ground water usually is more highly mineralized than surface water because it remains in contact with rocks and soils for much longer periods. Water quality can also be altered by chemical reactions, biological influences, and mixing with interconnected aquifers.

Existing knowledge regarding ground water quality was derived principally from the county ground water studies prepared by the U.S. Geological Survey in cooperation with the State Water Commission, the State Geological Survey and the respective Water Management Districts.

The following disucssions are general observations of the ground water characteristics in the planning area. The discussions are arranged by geologic formations with emphasis placed on the variability of the quality characteristics.

Glacial Aquifers

The buried valley aquifers, buried glaciofluvial aquifers and those aquifers classified as Pleistocene were grouped and analyzed as glacial aquifers. These aquifers are found in the glaciated portions of the West River Area.

The largest yields and best quality water in the entire area are from these relatively undeveloped aquifers. Sodium bicarbonate water is the most common type although calcium bicarbonate and calcium sulfate types also occur. Chlorides are found in small amounts, usually in amounts less than 5 percent of the total anions. Magnesium usually accounts for 15 to 20 percent of the total cations. The water in the glacial aquifers is moderately hard to hard (120-680 mg/l).

Although specific conductance from the glacial aquifers ranged from 480 to over 5,000 micromhos, most contain waters with a specific conductance of 1,200 to 2,200 micromhos. Water from the deeper sands generally contains higher levels of dissolved solids. This indicates a degree of stratification in the glacial aquifers and waters withdrawn from a particular well could represent a

10/ Source: The West River Study, Appendix B Hydrology, North Dakota State Water Commission, SWC Project 1543, Series 30.

mix of waters from several depths. The sodium adsorption ratio of the majority of wells was below 10 although a range from 0.1 to 43 was noted. The water samples in the Heart River Basin were variable but the total dissolved solids were generally higher than those in the Knife River Basin.

Sentinel Butte Aquifer

The Sentinel Butte Aquifer is found throughout the Knife River Basin, the upper two-thirds of the Heart River Basin and the upper one-third of the Cannonball River Basin. The Sentinel Butte Aquifer is lignitic and highly variable in chemical quality.

The deeper wells in the Heart and Knife River Basins generally are a sodium bicarbonate type. Calcium and sulfate waters are common in the shallower aquifers and in the Cannonball River Basin. Chlorides are low in all areas. The water usually is soft in wells deeper than 175 feet and moderately hard to very hard in the shallower wells. Conductance is the highest in the Knife River Basin (2,300-5,000 micromhos) and lowest in the Cannonball River Basin (usually under 2,000 micromhos with a few wells as high as 4,000 micromhos). The sodium adsorption ratio ranges from very low to high. The wells deeper than 175 feet usually have high sodium adsorption ratios while the shallower wells are variable.

Tongue River Aquifer

The Tongue River Aquifer is found in most areas with the exception of the southeastern and southwestern portions of the planning area. The Tongue River Aquifer often is found in lignite beds but is not as variable in water quality as the aquifer previously discussed.

The wells in all areas produced water high in sodium and bicarbonate, especially in the Knife River Basin. The water is very soft and low in chlorides and sulfates. Conductivities usually were greater than 3,000 micromhos in the Knife River Basin and less than 2,000 micromhos in the Heart and Cannonball River Basins. The sodium adsorption ratios are very high (730) in most areas although a few low ratios were found in the Cannonball River Basin.

Tongue River-Ludlow Aquifer

The Upper Ludlow and Basal Tongue River Aquifers are extremely variable in water chemistry. All data are from wells in Adams and Bowman Counties. Sodium bicarbonate waters are the most common type but calcium and sulfates were found in very high concentrations in a few wells. Conductivities ranged from less than 1,000 to over 3,000 micromhos. The sodium adsorption ratios of the waters also are extremely variable (0.6-64). The shallower wells usually are less mineralized than the wells over 150-200 feet deep.

Ludlow-Cannonball Aquifer

The aquifer found in the Ludlow-Cannonball formation also varies in water chemistry. These waters are a sodium bicarbonate type and are very soft. Conductivities vary from 1,000 to over 3,000 micromhos. The sodium adsorption ratios are high for all water with a range from 18 to over 80. Sulfate concentrations varied from low to very high (0-12,000 mg/l). Chlorides generally were low.

Hell Creek-Fox Hills Aquifer

The Hell Creek-Fox Hills Aquifer is found throughout the planning area with the exception of the extreme southwestern portion of Bowman County. The water from the aquifer analyzed was all a sodium-bicarbonate type. The water generally was soft. Sodium usually accounted for at least 95 percent of the cations. As a result, the sodium adsorption ratio for all waters was high (20-95). Bicarbonates dominated the anions in all but one well. On the average, bicarbonates accounted for 75 percent of the anions. Chloride concentrations accounted for 16 percent of the anions, a significant increase from the previously discussed aquifers. Sulfates were extremely variable, accounting for 9 percent of the anions on the average.

Specific conductance in the deeper wells in the Knife River Basin (900 to 1,935 feet deep) vary from 1,800-3,200 micromhos with the majority of wells between 2,200-2,500 micromhos. The highest sodium concentrations are obtained in wells

in the Knife River Basin. The wells in Stark and Grant Counties are 450 to 1,780 feet deep. The specific conductance range from 1,910 to 3,300 micromhos with the majority of the wells between 2,000 and 2,200 micromhos. The wells in Adams and Bowman Counties range in depths from 80 to 1,200 feet. Specific conductances vary from 1,500 to 2,000 micromhos. Sodium concentrations are high but less than those in Dunn, Mercer, Stark, and Grant Counties.

Dakota and Minnelusa Aquifers

These aquifers have been penetrated by oil and gas test holes and generally contain brackish or saline water. The Dakota Group, an important aquifer in eastern North Dakota, is at depths greater than 3,500 feet in Mercer County. The water has a conductivity of 7,000 to 10,000 micromhos. The Minnelusa formation is found at depths 5,000 feet or deeper and has a conductivity of 10,000 to 20,000 micromhos.

CHAPTER III

SOCIOECONOMIC CHARACTERISTICS

Population

Some 99,000 persons inhabit the North Dakota Tributaries planning area at the present time (table III-1). That number represents a 1.3 percent increase over the 1970 population. Prior to 1970 the area had been losing population as had the entire State of North Dakota. Even though the population of the area has grown, about one-half of the counties are still experiencing population declines. Most of the 5-year growth in the area occurred in Morton and Sioux Counties.

Compared to the State, the southwestern part of North Dakota has grown more slowly. As a consequence, the percentage of the State's people who reside in this area has declined since 1960.

Rural and Urban Population

The majority of area residents live in rural areas. Even though the percentage living in rural areas has declined since 1960, it still exceeded 75 percent in 1970 (table III-2).

The rural net outmigration that occurred between 1960 and 1970 was mainly from farms. There were fewer rural nonfarm people in 1970 but they represent a higher percent of total population than they did in 1960.

Southwest North Dakota is more rural than the State (table III-2). Relatively more of those who live in rural areas in the planning area live on farms when compared to the State. The strong agrarian nature of the area helps explain the people's expressed desire for maintaining a strong agricultural tradition.

The largest towns are Dickinson and Mandan. Dickinson is the most centrally located and provides services to much of southwest North Dakota.

Table III-1. Population Estimates of North Dakota Tributary Counties

County	1960 1/	1970 2/	1975 2/	% Change 1960-70	% Change 1970-75
Adams	4,449	3,832	3,700	-13.9	- 3.4
Billings	1,513	1,198	1,200	-21.2	+ .2
Bowman	4,154	3,901	4,100	- 6.1	+ 5.1
Dunn	6,350	4,895	4,600	-22.9	- 6.0
Golden Valley	3,100	2,611	2,500	-15.8	- 4.3
Grant	6,248	5,009	5,100	-19.8	+ 1.8
Hettinger	6,317	5,075	4,700	-19.7	- 7.4
McKenzie	7,296	6,127	6,000	-16.0	- 2.1
McLean	14,030	11,251	11,500	-19.8	+ 2.2
Mercer	6,805	6,175	6,200	- 9.3	+ .4
Morton	20,992	20,310	21,600	- 3.2	+ 6.4
Oliver	2,610	2,322	2,400	-11.0	+ 3.4
Sioux	3,662	3,632	4,200	- .9	+15.6
Slope	1,393	1,484	1,400	-21.6	- 5.7
Stark	18,451	19,613	19,500	+ 6.3	- .6
North Dakota Tributaries	107,870	97,435	98,700	- 9.7	+ 1.3
State of North Dakota	632,446	617,792	637,000	- 2.3	+ 3.1
Percent of State	17.1	15.8	15.5	-	-

1/ U.S. Bureau of the Census, County and City Data Book, 1967 (A Statistical Abstract Supplement), U.S. Gov't Printing Office, Washington, D. C., 1967
2/ U.S. Bureau of the Census, Estimates of the Population of North Dakota Counties and Metropolitan Areas, July 1, 1974 and 1975, Series P-26, No. 75-34, July 1976. Note that this source contains most recent adjustments to 1970 Census; therefore, figures may not be identical to previously published Census estimates.

Table III-2. Rural and Urban Population for North Dakota 1960 and 1970[1/]

	North Dakota Tributaries				State of North Dakota			
	1960		1970		1960		1970	
	No.	%	No.	%	No.	%	No.	%
Urban[2/]	20,495	19.0	23,481	24.1	223,000	35.3	273,350	44.2
Rural	87,375	81.0	73,953	75.9	409,446	64.7	344,442	55.8
Farm[3/]	46,276	42.9	33,907	34.8	204,222	32.3	152,195	24.6
Nonfarm[4/]	41,099	38.1	40,046	41.1	205,224	32.4	192,247	31.2
Total Population	107,870	100.0	97,435	100.0	632,446	100.0	617,792	100.0

1/ Based on report of OBERS Projections for Population, Income and Employment Ad Hoc Work Group.
2/ Urban inhabitants are defined as persons living in places of 2,500 inhabitants or more.
3/ Rural farm inhabitants are defined as persons living on 10 or more acres with farm sales of $50 or more in the preceding calendar year or on places of less than 10 acres with farm product sales of $250 or more in the preceding calendar year.
4/ Rural nonfarm are persons not meeting the urban or rural farm definitions.

Educational Attainment

Formal education is one way in which people accumulate knowledge. However, education by itself is not a measure of capabilities. Knowledge of educational levels may provide public decisionmakers useful insights about the types of public programs needed as well as potential training needs for specific skills. Table III-3 shows the distribution of educational levels for the planning area, North Dakota, and the United States. The most striking difference in educational attainment between the planning area and the United States is that nearly one-half the people 25 years or older in the area have an eighth-grade education or less, whereas only 28 percent of the United States people 25 years or older fall in this category. The high percentage of rural residents in the planning area is part of the reason for this situation, since in general, rural people usually have completed fewer years of formal education than urban people. Again, it must be stressed that this means very little other than that differences do exist.

Age Distribution

The age distribution of the people in an area can be useful information. Service and recreational needs vary among people by age groups. Age groups participate to various extents as part of the labor force. The general attitudes of an area differ by age.

There are relatively more people under 18 years of age in the North Dakota Tributaries area than there are in either the State of North Dakota or the United States (table III-4).

Table III-3. Years of School Completed by Persons 25 Years of Age and Older 1/

Level	North Dakota Tributaries		North Dakota	United States	Urban	
					North Dakota	United States
	No.	%	%	%	%	%
Elementary						
0 to 8 Years	8,593	17.2	12.8	15.5	9.9	14.2
8 Years	15,458	31.0	25.7	12.7	18.5	11.4
High School						
Less Than 4 Years	5,390	10.8	11.0	19.4	10.3	19.2
4 Years	11,861	23.8	27.6	31.1	30.2	31.6
College						
Less Than 4 Years	5,573	11.2	14.4	10.6	17.4	11.5
4 Years or More	2,968	6.0	8.5	10.7	13.7	12.1
	49,843	100.0	100.0	100.0	100.0	100.0

1/ U.S. Bureau of the Census, Census of Population, 1970, Washington, D. C.

Table III-4. General Age Distribution of Inhabitants in the North Dakota Tributaries, North Dakota and the U.S.[1/]

	North Dakota Tributaries		State of North Dakota		United States	
	1960	1970	1960	1970	1960	1970
			Percent			
Under 18 Years	43.4	40.0		36.7	35.9	34.3
18 to 64 Years	48.4	50.1		52.6	55.1	55.8
65 Years and Older	8.2	9.9		10.7	9.0	9.9
Median Age	23.1	26.7	26.2	26.4	29.5	28.3

1/ U.S. Bureau of the Census, Census of Population for 1960 and 1970.

Income and Income Distribution for Families

An individual's income traditionally has been looked upon as the major determinant of how "well off" or how satisfied that individual is, with society tended to be geared to the idea that "more" means "better." There are indications, however, that more does not necessarily mean better to many people. Many elements must be considered in determining whether or not one group is "better off" than another. Unfortunately, methods for expressing some of these other items, e.g., a preference for living in a small town versus a large city, in a common denominator do not exist. Information regarding income levels, on the other hand, is readily available. The point is, income data must be viewed in its proper perspective, which is, as only one element of many that provides an insight into an area's overall well-being.

The distribution of families by income class and the average and median incomes are shown in table III-5. Several things can be learned from this table. First of all, the average income of families for the planning area is lower than that for the State or the U.S. This is influenced by the rural nature of the area. The median family income is the income level that is in the middle or the 50th percentile. In other words, there are as many families with incomes above the median as below it.

In the North Dakota Tributaries area over 57 percent of the families receive less than the average income. The percentage receiving less than the respective area average is similar for the State and the Nation. The latter indicates that income is not uniformly distributed in any of the areas. Some believe that efforts to reduce the variation in income levels is good. Completion of the social well-being account in Principles and Standards[11/] could be aided by displaying project and plan effects on income distribution. However, the level of detail necessary to determine such effects is greater than normally will be found in a Level B effort.

11/ U.S. Water Resources Council, Water and Related Land Resources, Establishment of Principles and Standards for Planning. Federal Register, Vol. 38, No. 174, Part 3, September 10, 1973.

Table III-5. Income and Income Distribution of Families in North Dakota Tributaries, North Dakota and the U.S. - 1970 1/

Family Yearly Income 2/	North Dakota Tributaries All Families	State of North Dakota All Families	United States			
			Total	Urban	Rural Nonfarm	Rural Farm
Dollars	Percent					
Less Than 2,000	8.5	6.5	5.9	4.9	8.1	10.4
2,000 to 3,999	15.5	12.4	9.3	8.1	11.9	14.8
4,000 to 5,999	17.1	15.9	10.8	9.8	13.0	15.3
6,000 to 7,999	16.5	16.5	12.8	12.1	15.1	14.3
8,000 to 9,999	13.7	14.4	13.9	13.6	14.9	12.6
10,000 to 14,999	19.3	21.4	26.6	28.0	23.8	19.2
15,000 to 24,999	7.8	9.9	16.0	18.0	10.7	9.9
25,000 and Over	1.6	3.0	4.6	5.3	2.6	3.3
Average Income ($)	8,084	9,086	10,999	11,674	9,251	8,795
Median Income ($)	7,058	7,838	9,590	10,196	8,248	7,296

1/ Source: U.S. Bureau of Census: 1970, "General Social and Economic Characteristics

2/ Income is the sum of wager or salary income, nonfarm net self-employment incomed, farm net self-employment income social security or railroad retirement, welfare income, and all other income which includes income from interest, dividends, rentals, public and private persons, etc.

Earnings by Sector and Per Capita Personal Income

Certain sectors of an economy are considered to be basic to the economy while others are nonbasic. Basic sectors are those whose output exceeds local needs and therefore results in exports to areas outside the local economy. The nonbasic sectors depend on new income generated by the basic sectors for their output. Most sectors have some elements of both basic and nonbasic, for example, the retail sector sells items to agriculture in the area which would be a nonbasic sale. Sales by the retail sector to non local tourists would be a basic type sale. Formal techniques exist for estimating whether or not a given sector is basic. The use of these techniques is beyond the scope of this report. However, the nature of the local sectors and the local economy gives a reasonable indication of basic and nonbasic sectors.

Agriculture, when all activities are lumped together, is a basic sector. Coal mining at the present time in the area is probably nonbasic since most of the coal is used within the local economy for generation of electricity. The generation of electricity, on the other hand, is largely basic since much of the electricity is exported out of the area. Manufacturing is another basic industry.

Examination of tables III-6 and III-7 provides some useful insights into the area economy. For each of the five years shown, farm earnings[12/] are by far the most important. None of the other sectors even approach the earnings generated by the farm sector. The figures shown in table III-6 are in constant 1975 dollars which means that the figures have been increased to reflect the general inflation level of 1975. The year-to-year fluctuations are caused by production and price changes. One must realize that price changes occur for reasons other than inflation. Consequently, if agricultural prices go up due to demand and supply changes,

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12/ Earnings are the sum of wages and salaries, other labor income and proprietor's incomes in each industry (U.S. Water Resources Council, 1972 OBERS Projections, Series E Population, Vol. 1, p. 21). These are estimated by place of work.

Table III-6. Personal Income and Earnings by Sector, 1970-1974, North Dakota Tributaries 1/

	1970	1971	1972	1973	1974
Total Personal Income (1975 $1,000)	353,838	364,505	429,331	573,010	472,886
Per Capita Income (1975 $)	3,619	3,692	4,363	5,850	4,782
Per Capita Income Relative (U.S. = 1)	.68	.68	.77	.98	.82
		Thousands of 1975 Dollars			
Total Earnings	258,089	265,157	321,358	460,988	358,690
Farm	74,963	79,185	123,171	249,672	135,202
Mining	3,176	3,106	3,018	5,505	7,592
Contract Construction	12,707	12,900	15,153	21,994	30,550
Manufacturing	13,471	14,954	16,788	16,901	17,826
Trans., Comm. & Public Utilities	17,597	18,696	20,347	23,561	22,472
Wholesale & Retail Trade	45,060	46,382	46,342	51,530	54,244
Finance, Insurance & Real Estate	6,154	6,520	6,937	6,881	7,030
Services	26,193	25,381	28,116	28,743	28,953
Federal Civilian Government	13,000	13,565	16,022	14,706	14,351
State & Local Government	29,417	30,349	32,377	32,362	30,137
Armed Forces	2,430	2,597	2,732	2,845	2,732
Other & Unaccounted For 2/	13,948	11,522	11,355	6,288	7,601

1/ U.S. Dept. of Commerce, Bureau of Economic Analysis, Regional Economics Information System, August 6,1976

2/ Due to disclosure problems earnings for some sectors for some counties could not be included in the proper sector, but it is included in the total. Consequently, some of these earnings belong to one or more of the other sectors but there is no way of knowing which sector and how much.

Table III-7. Percent of Total Earnings by Sector, 1970-1974, North Dakota Tributaries 1/

Sector	Percent of Total Earnings				
	1970	1971	1972	1973	1974
Farm	29.0	29.8	38.3	54.1	37.6
Mining	1.2	1.2	.9	1.2	2.1
Contract Construction	4.9	4.9	4.7	4.8	8.5
Manufacturing	5.2	5.6	5.2	3.7	5.0
Trans., Comm. & Public Utilities	6.8	7.1	6.3	5.1	6.3
Wholesale & Retail Trade	17.5	17.5	14.4	11.2	15.1
Finance, Insurance & Real Estate	2.4	2.5	2.2	1.5	2.0
Services	10.2	9.6	8.7	6.2	8.1
Federal Civilian Government	5.1	5.1	4.7	3.2	4.0
State & Local Government	11.4	11.4	10.1	7.0	8.4
Armed Forces	.9	1.0	1.0	.6	.8
Other & Unaccounted For	5.4	4.3	3.5	1.4	2.1

1/ Based on information from Table III-6.

those adjustments are likely to be reflected in the constant dollar figures of table III-6. Total earnings in 1973 increased by about $140 million. The increase in the farm sector alone amounts to $126 or 90 percent of the total. In 1974, total earnings fell by about $102 million. The decline in the farm earnings for 1974 amounted to over $114 million. The reasons for these large changes in the farm sector will be examined in a later section.

Also, notice how total personal income[13/] and per capita income are affected by the farm sector. In 1973, average per capita income in the study area was about equal to the U.S. average. With the falling agricultural earnings encountered in 1974 came a falling per capita income situation for the area. In general, per capita personal income has been below that for the United States. The strong dependency of this region on agriculture helps explain the relative position.

Employment

Sector Employment

Another way of viewing the importance of various sectors is to look at employment. Employment numbers provide a picture of the various sectors that can be different from the picture provided by earnings.

Examination of sector employment over time gives some indication of each sector's growth. While employment does not directly reflect output it does give one an indication of output growth or decline that is not masked by price changes. For most nonagricultural sectors output tends to grow along with employment. Since labor productivity continues to increase in the farm sector output goes up but employment goes down; consequently, if growth means increasing real output, employment

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13/ Personal income "consists of wages and salaries (in cash and in kind, including tips and bonuses as well as contractual compensation), various types of supplementary earnings termed other labor income (the largest item being employer contributions to private pension, health and welfare funds), the net incomes of owners of unincorporated businesses (farms and nonfarm with the latter including the incomes of independent professionals), net rental income, dividends, interest, and government and business transfer payments (consisting in general of disbersements to persons for which no services are rendered currently, such as unemployment benefits, social security payments and welfare and relief payments)". U.S. Water Resources Council, 1972 OBERS Projections, p. 20.

Table III-8. Employment by Type and Broad Industrial Sources, Full and Part-Time Wage and Salary Employment Plus Number of Proprietors[1/] for North Dakota Tributaries

	1970	1971	1972	1973	1974
TOTAL EMPLOYMENT	39,564	39,555	40,007	41,127	43,383
Number of Proprietors	15,478	15,440	15,429	15,201	15,108
Farm Proprietors	10,856	10,642	10,428	10,213	10,104
Nonfarm Proprietors	4,622	4,798	5,001	4,988	5,004
Wage and Salary Employment	24,086	24,115	24,578	25,932	28,275
Farm	1,661	1,817	1,660	1,658	1,827
Non Farm	22,425	22,298	22,918	24,268	26,448
Government	7,081	6,900	6,825	6,987	7,548
Total Federal	1,254	1,221	1,277	1,207	1,233
Federal Civilian	1,231	1,198	1,259	1,184	1,207
Military	23	23	18	23	26
State and Local	5,827	5,679	5,548	5,780	6,315
Private Nonfarm	15,344	15,398	16,093	17,281	18,900
Manufacturing	1,169 D[2/]	1,259 D	1,360 D	1,374 D	1,502
Mining	174 D	183 D	181 D	348 D	492
Construction	1,024 D	996 D	1,155 D	1,657 D	2,188
Trans., Comm. & Public Util.	1,658 D	1,488 D	1,492 D	1,723	1,698 D
Wholesale & Retail Trade	5,510 D	5,580 D	5,350 D	5,906	6,289
Finance, Ins. & Real Estate	527 D	556 D	622 D	654 D	715
Services	3,875 D	3,881 D	4,520 D	4,777 D	5,067 D
Other	48 D	141 D	144 D	56 D	51 D

1/ Compiled by North Dakota State Planning Division, data from U.S. Dept. of Commerce, Bureau of Economic Analysis (BEA), Regional Economics Information System.
2/ A "D" indicates that data for one or more counties is not included due to nondisclosure policies of BEA. Total for private nonfarm is correct.

could provide a distorted view for the farm sector.

Another use of sector employment figures is for determining the types of sectors that are requiring additional labor. Such information can be helpful to educational planners and to young people who want to stay in a particular area.

Employment by sector is shown in table III-8. Total employment grew almost 10 percent from 1970 through 1974. The farm sector experience almost a 5 percent decline in total employment (proprietors plus wage and salary employment) over the same time period. Employment in the private nonfarm sectors expanded by almost 20 percent over the five years.

Due to nondisclosure problems it is somewhat difficult to tell which non-farm sectors experienced the largest growth. It appears that "construction" was one of the larger gainers along with the trade sector. The disclosure problems for these two sectors do <u>not</u> appear to be serious enough to invalidate the trend shown. In fact, in the trade sector, data were suppressed in only one county (Billings) for three years. The service sector also shows significant growth in employment. Disclosure problems appear to make this growth appear somewhat larger than it probably really was; however, the growth was still significant.

Government employment grew over 6.5 percent during the 1970-1974 period. All of the growth occurred at the State and local levels.

<u>Unemployment Rate</u>

Even though total employment has grown as shown in table III-8, there is still concern about unemployment. In some instances, growing employment is off-set by even greater growth in the size of the work force. The latter is reflected in table III-9, where it is shown that the unemployment rate grew from 1972 to 1973. Since 1973 the unemployment rate has fallen.

The unemployment rate in the North Dakota Tributaries area was higher than the State and the U.S. from 1972-1975, except for 1975 when the area's unemployment rate was lower than the national. The falling unemployment rate in the planning area

Table III-9. Average Annual Unemployment Rates, Counties of North Dakota Tributaries, 1972 Through 1975[1/]

Area	1972	1973	1974	1975
	Percent			
Adams	2.8	2.7	3.1	3.8
Billings	4.2	4.6	4.7	7.2
Bowman	4.1	3.7	4.8	3.1
Dunn	8.5	8.5	6.9	9.3
Golden Valley	2.5	3.4	3.3	4.7
Grant	6.6	7.0	6.3	5.8
Hettinger	5.7	5.9	5.9	5.0
McKenzie	4.1	3.6	3.4	4.1
McLean	8.7	9.1	8.2	6.9
Mercer	6.1	5.8	4.9	5.5
Morton	8.4	8.5	8.2	7.0
Oliver	8.6	10.3	6.7	5.5
Sioux	7.9	8.7	7.5	8.4
Slope	4.5	4.8	4.9	5.3
Stark	6.2	5.4	5.4	5.0
Study Area	6.3	6.6	6.1	5.8
State of North Dakota	4.9	5.1	5.0	4.9
United States	5.6	4.9	5.6	8.5

1/ State of North Dakota, Employment Security Bureau, 1976, and Council of Economic Advisors, Economic Indicators, September 1976.

since 1973 was probably due to stronger agricultural income and activity associated with energy development.

Notice that the unemployment rate is quite different between counties. In 1975, Adams County had the lowest unemployment rate of 3.8 percent, while Dunn County had the highest at 9.3 percent.

Agriculture

From the evidence indicated, agriculture is by far the most important sector of the area economy. The expenditures by the farm sector for the purchase of inputs (e.g., fertilizer, fuel, machinery) are crucial to the output of other sectors such as trade. If agriculture were to disappear, many other sectors would disappear also. Undoubtedly, the economy will change over time, but it does not appear that agriculture will ever be unimportant. To some people a farm is just another factory, but to many it represents a way of life. Most people in the area seem to be satisfied with their present way of life which is heavily associated with farming and ranching.[14]

Farm Size and Income

According to farm numbers and employment, the number of people who work and live as farmers or ranchers is declining. The number of farms (which includes ranches) in the study area in 1974 was only 71 percent of the number existing in 1949 (table III-10). The rate of decrease in farm numbers appears to have slowed somewhat since 19[illegible]. Correspondingly, average farm size has gone up over 50 percent since 1949.

It is instructive to examine the value of agricultural products sold, shown in table III-10. Part of the increase [illegible] is due to increased production. However, a large part of the increase, particularly between 1969 and 1974 was due to prices. In 1969, the index representing the prices received by North Dakota farmers for all farm products stood at [illegible] (1964-1966 = 100) while in 1974 the

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14/ North Dakota State Water Commission, The West River Study, "An Analysis of Alternatives for Developing and Managing the West River Area's Water and Related Land Resources - Main Report", Information Series No. 30, January 1, 1975, p.137.

Table III-10. Farm Size, Value of Production and Farm Expenses
North Dakota Tributaries1/

	1949	1954	1959	1964	1969	1974
Number of Farms	13,423	12,696	11,263	10,151	9,970	9,571
Land in Farms (Acres)	11,993,241	12,393,383	12,081,843	13,308,130	13,158,888	13,022,561
Average Farm Size (Acre/Farm)	893	976	1,073	1,311	1,320	1,360
Total Value of All Ag. Products Sold ($1,000)	72,898	65,518	85,293	103,304	147,280	304,613
Value of Crops Sold ($1,000)	36,283	35,180	29,697	51,067	64,597	182,813
Percent of Total	49.8	53.7	34.8	49.4	43.9	60.0
Value of Livestock, Poultry & Their Products Sold ($1,000)	36,603	30,331	55,587	52,224	82,681	121,796
Percent of Total	50.2	46.3	65.2	50.6	56.1	40.0
Value of Forest Products Sold ($1,000)	12	7	10	13	2	4
Percent of Total	0.0	0.0	0.0	0.0	0.0	0.0
Farm Production Expenses2/ ($1,000)	-	-	-	-	111,974	188,809

1/ Data source is U.S. Bureau of the Census, Census of Agriculture, data for all farms.
2/ Not available for all farms until 1969

same index was at 253 (1966-1968 = 100).[15] Total value of production doubled in five years, but prices went up two and one-half times.

Livestock and livestock products have tended to account for over 50 percent of total value of agricultural products sold. The major exception was 1974 when only 40 percent of total value came from livestock. Examination of price indexes is again instructive. In 1974, the all crop price index was 316 (1966-1968 = 100) while the all livestock products price index (same base) was 152. In 1969 these same indexes were 116 for crops and 114 for livestock. The implication is that there was a major change in relative position between crop and livestock prices in 1974 so it is probably not a typical year.

The reader may recall that farm earnings (table III-6) dropped substantially from 1973 to 1974. The price indexes help explain some portion of that event. In 1973, the all crop index for prices received by farmers was 198 compared to 317 in 1974. The all livestock products price index was 191 in 1973 and 152 in 1974. In other words, crop prices rose significantly and livestock prices fell significantly. Southwest North Dakota tends to be more of a livestock area than a crops area; therefore, earnings were hurt. In addition, production for the major cash crop of the area (wheat) was 4 million bushels lower in 1974 compared to 1973. Also, oats and barley production was substantially lower in these counties during 1974. A third element that enters the picture is farm expenses. While total receipts appeared to be down in 1974 compared to 1973 in the study area, production expenses went up about 16 percent.[16] All of these elements combined to substantially reduce farm earnings in 1974.

The point is that because agriculture is so important and because it is

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15/ U.S. Dept. of Agriculture, SRS, North Dakota Crop and Livestock Statistics, Annual Summary for 1970, Revisions for 1969, May 1971, and Annual Summary for 1975, Revisions for 1974, May 1976.

16/ Based on state level increase as shown in Statistical Reporting Service, USDA, North Dakota Crop and Livestock Statistics, Ag. Stat. No. 38, May 1976, p. 62.

highly variable due to climatic and market conditions, the regional income picture is also highly variable. Planning and actions to reduce regional income variability are considered desirable.

One often overlooked aspect of agriculture is the expenditures made by that sector for other items. Even when earnings and net income are down for farmers, these farmers still must buy about the same amounts of items; consequently, short term income variations are probably not felt very strongly by the supplying sectors such as trade. Additionally, farmers and ranchers tend to purchase many of their items locally so they do generate large amounts of business for local merchants. Farm production expenses had approached $189 million by 1974 in the study area. A large part of that $189 million expenditure was gross sales for local business.

If farm income were depressed over several years, the supplying sectors would start to feel the crunch also. The likelihood of such an event is probably higher due to weather than due to market conditions. Several years of drought could force liquidation of cow herds and reduced crop yields especially since the area has very little irrigation.

Crop and Livestock Production

Wheat is and has been the largest crop in the area (tables III-11 and III-12). More wheat is now grown on fewer acres than in 1949. Similar statements can be made for most other crops. Productivity increases reflect improved technology and better management.

Hay and feed grain production has gone up steadily. The production of these latter crops is used locally to produce livestock. As a consequence the value of crops sold does not reflect these levels of production. The value of the roughage and feed grain crops is realized indirectly through sales of livestock.

Table III-11. Historical Production of Irrigated and Nonirrigated Crops 1/
North Dakota Tributaries

Crop	Unit	1949	1954	1959	1964	1969	Base
Wheat	Bu.	19,306,936	14,868,793	15,787,249	28,718,095	38,353,543	40,584,300
Rye	Bu.	121,219	736,206	294,004	1,108,089	686,914	530,517
Corn for Grain	Bu.	846,284	958,622	34,908	134,284	283,349	128,333
Silage	Tons	-	504,782	493,432	627,585	534,786	538,670
Oats	Bu.	3,722,790	7,173,389	3,218,525	14,467,421	24,365,953	19,444,633
Barley	Bu.	1,338,266	4,039,532	4,402,737	7,442,403	6,739,856	10,156,533
Hay	Tons	642,638	907,692	648,295	1,007,001	1,109,716	1,406,033
Soybeans	Bu.	40	2,387	-	80	9,738	9,738 2/
Flaxseed	Bu.	1,083,299	2,219,255	325,120	933,601	1,083,688	525,900
Sugar Beets	Tons	30,541	39,373	38,081	73,032	112,330	113,767
Irish Potatoes	Cwt.	224,529	195,387	52,304	83,709	183,100	183,100 2/
Dry Beans	Cwt.	-	18,089	21,647	39,734	25,394	25,394 2/

1/ Source of data is U.S. Agricultural Census for years 1949 through 1969. The base is an average of Statistical Reporting Service data for years 1972 through 1974 unless noted otherwise.
2/ Agricultural Census for 1969 is most current county estimate available.

Table III-12. Historical Acres of Major Crops Harvested1/
North Dakota Tributaries

Crop	Unit	1949	1954	1959	1964	1969	Base
Wheat	Ac.	2,295,979	1,875,080	1,582,317	1,496,013	1,542,497	1,654,167
Rye	Ac.	16,566	51,025	31,128	57,082	32,171	18,167
Corn for Grain	Ac.	50,779	59,434	3,842	6,841	8,072	3,800
Silage	Ac.	248,559	343,151	477,537	298,396	145,689	102,600
Oats	Ac.	212,457	371,993	228,306	376,237	452,941	461,037
Barley	Ac.	116,029	274,028	391,720	260,860	175,023	277,003
Hay	Ac.	925,515	857,286	1,093,127	899,687	831,051	1,093,667
Flaxseed	Ac.	227,925	511,643	112,342	98,556	94,543	54,633
Sugar Beets	Ac.	3,187	4,284	4,369	7,602	9,836	6,087
Irish Potatoes	Ac.	3,832	2,323	1,197	875	2,540	2,540 2/
Dry Beans	Ac.	-	1,413	1,999	2,716	1,961	1,961 2/

1/ Source of data is U.S. Agricultural Census for years 1949 through 1969. The base is an average of Statistical Reporting Service data for years 1972 through 1974 unless noted otherwise.
2/ Agricultural Census for 1969 is most current county estimate available.

Cattle and calves are the most important livestock produced in the area. Numbers of cattle and calves in the study area have more than doubled since 1949 (table III-13). Sheep and lamb numbers peaked in the late 1950's and have gone down drastically since. Current sheep numbers are about one-third the size that they were in 1959. Milk cow numbers have also steadily declined since 1949.

Table III-13. Number of Head of Livestock[1/]
North Dakota Tributaries

Livestock	Unit	1949	1954	1959	1964	1969	Base
All Cattle & Calves	#	492,680	673,531	617,492	810,743	735,252	1,013,000
Milk Cows	#	80,379	76,144	63,381	59,610	41,533	40,500
All Sheep & Lambs	#	79,489	144,837	184,308	152,234	131,293	69,500
All Hogs & Pigs	#	75,250	125,671	112,123	74,727	68,058	75,000
Chickens 4 Months & Older	#	607,813	810,943	583,388	399,190	182,114	182,114[2/]
Horses & Ponies	#		27,234			13,392	13,392[2/]

1/ Source of data is U.S. Agricultural Census for years 1949 through 1969. The base is 1974 data from Statistical Reporting Service.
2/ Agricultural Census for 1969 is most current county estimate available.

CHAPTER IV

PROJECTED REQUIREMENTS - 1985 - 2000

Source of Projections

The source of the material used in this chapter was the Ad Hoc Group reports developed for this study. Projections for the North Dakota portion of the study were gleaned from these reports and are presented here as the projected needs for each of the individual functional areas. For a more detailed explanation of the methodology used for each functional area the reader is referred to the individual ad hoc group reports.

Projections 1985-2000

Energy[17/]

The study of energy consisted of two major components; 1) a "macro" level analysis which considered national energy supply and demand interaction and 2) a "micro" level analysis which focuses on the energy development activity of the Yellowstone study area. For full details of this macro and micro analysis the reader is referred to the Analysis of Energy Projections and Implications for Resource Requirements, conducted for the MRBC by the Harza Engineering Company.

A summary of projected demands for North Dakota coal development with various constraints imposed are shown in table IV-1.

The low level of development shown in table IV-1 considered restraining energy development to the 1975 level. Because of ongoing construction and other commitments of industry and government this is impractical, however, it does provide a baseline for comparison of other energy development levels.

The most probable level shows coal production in the North Dakota planning area as 10.6 percent and 22.1 percent of the Yellowstone study area total for 1985 and 2000, respectively, while the coal conversion is 73.7 percent and 62 percent of the total conversion in the Yellowstone study area for 1985 and 2000, respectively

17/ See Analysis of Energy Projections and Implications for Resource Requirements, Harza Engineering Company, December 1976.

TABLE IV-1 SUMMARY OF ENERGY RELATED

RESOURCE REQUIREMENTS IN NORTH DAKOTA STUDY AREA

	Low (1975 level)		Most Probable		High		ND Limited	No Conversion	
	1985	2000	1985	2000	1985	2000	2000	1985	2000
Coal Production (million tons/year)	11	11	17.25	113.45	54.09	158.26	39.43	3.08	43.80
BTU Content (million BTU/ton)			13.57	13.57	13.57	13.57	13.57	13.57	13.57
Coal consumption (million tons/year)									
study area generation			6.86	30.13	24.32	28.34	28.77	3.04	2.97
syngas	0	0	10.30	83.00	10.30	104.00	10.30	.00	.00
Study area generation									
(megawatt capacity)	1222	1222	2914	9653	8870	8873	9323	1220	1220
(gigawatt hour/year)	7493	7493	9191	43251	34198	40806	41232	3941	3849
Water requirement (acre feet/year)									
mines	220	220	345	2269	1082	3165	789	62	876
reclamation	1639	1639	2571	16905	8060	23580	5875	459	6526
syngas	0	0	9986	80469	9986	100828	9986	0	0
study area generation	18733	18733	22978	118127	85494	102015	103079	9853	9621
slurry pipeline	0	0	0	0	11365	15191	0	0	0
total	20592	20592	35879	207769	115987	244779	119729	10374	17024
Labor requirement (man year-equivalent/year)									
mines	220	220	354	2278	1091	3300	797	67	882
syngas	0	0	624	5029	624	6301	624	0	0
study area generation	159	159	379	1255	1153	1153	1212	159	159
total	379	379	1357	8562	2868	10755	2633	226	1041
Capital requirement million dollars									
mines	26	26	48	510	225	775	155	0	195
syngas	0	0	998	8044	998	10079	998	0	0
study area generation	0	0	557	2764	2510	2508	2656	0	0
total	26	26	1603	11318	3733	13362	3809	0	195
Land requirements									
strip mining (acre/year)	421	421	661	4345	2072	6061	1510	118	1678
sites (acres)									
mines	494	494	518	3404	1623	4748	1183	92	1314
syngas	0	0	499	4024	499	5042	499	0	0
study area generation	1222	1222	2914	9653	8870	8875	9323	1220	1220
total	1716	1716	3931	17080	10992	18663	11006	1313	2534
Air pollutant emissions (tons/year)									
Particulates	733	733	5611	29807	18114	30655	21631	1971	1924
sulfur oxides	6110	6110	66291	349310	216331	357363	258535	23648	23091
nitrogen oxides	611	611	53401	276254	178435	279211	213605	19706	19243

The high level shows coal production in the North Dakota planning area as 18.3 percent and 20 percent of the Yellowstone study area total for 1985 and 2000, respectively, while the coal conversion is 88 percent and 55.5 percent of the total conversion in the Yellowstone study area for 1985 and 2000, respectively. The lower percentage of conversion within North Dakota from the most probable to the high level of development is due to the export of coal by slurry pipeline that takes place in the high level alternative.

The North Dakota limited scenario done by State request indicates that with limited coal production in North Dakota, for whatever reason, to 39.43 million tons per year (year 2000) the conversion will be very similar to the 1985 high level scenario. The no-conversion scenario indicates a decrease in coal production for 1985 from the existing 1975 level. This is reflected in the change of existing base load generating plants to an operation as intermediate load. The majority of the coal produced in the year 2000 under this scenario is exported by rail.

Agriculture18/

Agricultural projections were made by an ad hoc group of State and Federal representatives. The following tables (IV-2-IV-9) were extracted from that report.

The historic production of various commodities for the North Dakota study area for both irrigated and nonirrigated crops are shown in table IV-2. The production of wheat in the study area has doubled since 1949, table IV-2; while the acres harvested for wheat have decreased by 641,812 acres during the same period (table IV-3). Other crops in the study area have also had sustained increases in per acre yield as can be noted from table IV-2 and table IV-3.

The historic number of head of livestock in the North Dakota study area is shown in table IV-4. Since 1949, the cattle and calves have doubled while milk cows have decreased in number from 80,379 to 40,500 within the same time period.

18/ See Agricultural Projections and Supporting Data, Agricultural Ad Hoc Work Group Report, Montana, North Dakota, Wyoming, ERS, USBR, SCS, February 1977.

Table IV-2. Historical Production of Irrigated and Nonirrigated Crops 1/
North Dakota Tributaries

Crop	Unit	1949	1954	1959	1964	1969	Base
Wheat	Bu.	19,306,936	14,868,793	15,787,249	28,718,095	38,353,543	40,584,300
Rye	Bu.	121,219	736,206	294,004	1,108,089	686,914	530,517
Corn for Grain	Bu.	846,284	958,622	34,908	134,284	283,349	128,333
Silage	Tons	---	504,782	493,432	627,585	534,786	538,670
Oats	Bu.	3,722,790	7,173,389	3,218,525	14,467,421	24,365,953	19,444,633
Barley	Bu.	1,338,266	4,039,532	4,402,737	7,442,403	6,739,856	10,156,533
Hay	Tons	642,638	907,692	648,295	1,007,001	1,109,716	1,406,033
Soybeans	Bu.	40	2,387	---	80	9,738	9,738 2/
Flaxseed	Bu.	1,083,299	2,219,255	325,120	933,601	1,083,688	525,900
Sugar Beets	Tons	30,541	39,373	38,081	73,032	112,330	113,767
Irish Potatoes	Cwt.	224,529	195,387	52,304	83,709	183,100	183,100 2/
Dry Beans	Cwt.	---	18,089	21,647	39,734	25,394	25,394 2/

1/ Source of data is U.S. Agricultural Census for years 1949 through 1969. The base is an average of Statistical Reporting Service data for years 1972 through 1974 unless noted otherwise.
2/ Agricultural Census for 1969 is most current county estimate available.

Table IV-3. Historical Acres of Total Crops Harvested1/
North Dakota Tributaries

Crop	Unit	1949	1954	1959	1964	1969	Base
Wheat	Ac.	2,295,979	1,875,080	1,582,317	1,496,013	1,542,497	1,654,167
Rye	Ac.	16,566	51,025	31,128	57,082	32,171	18,167
Corn for Grain	Ac.	50,779	59,434	3,842	6,841	8,072	3,800
Silage	Ac.	248,559	343,151	477,537	298,396	145,689	102,600
Oats	Ac.	212,457	371,993	228,306	376,237	452,941	461,037
Barley	Ac.	116,029	274,028	391,720	260,860	175,023	277,003
Hay	Ac.	925,515	857,286	1,093,127	899,687	831,051	1,093,667
Flaxseed	Ac.	227,925	511,643	112,342	98,556	94,543	54,633
Sugar Beets	Ac.	3,187	4,284	4,369	7,602	9,836	6,087
Irish Potatoes	Ac.	3,832	2,323	1,197	875	2,540	2,540 2/
Dry Beans	Ac.	---	1,413	1,999	2,716	1,961	1,961 2/

1/ Source of data is U.S. Agricultural Census for years 1949 through 1969. The base is an average of Statistical Reporting Service data for years 1972 through 1974 unless noted otherwise.
2/ Agricultural Census for 1969 is most current county estimate available.

Sheep and hogs, while fluctuating somewhat, are essentially at their 1949 level. Chickens within this period have decreased substantially from 607,813 to 182,114 (table IV-4).

Future requirements for both crop and livestock were based on national projections made jointly by the Economic Research Service, USDA, and the office of Business Economics (now known as Bureau of Economic Analysis), Department of Commerce. These projections, known as OBERS (acronyn standing for OBE and ERS), were disaggregated to the study area by the Agricultural Ad Hoc Work Group. Two different levels or series of national projections were used -- Series E and Series E'. These two series are both based on the same future population expectations but differ in assumed levels of exports and per capita consumption rates.

The projected crop production for 1985 and 2000 for both series E and E' is shown in table IV-5. All crop production is projected to increase for both series E and E' with the exceptions of corn for grain and dry beans.

The projected livestock production for the North Dakota study area for series E and E' is shown in table IV-6. Beef and veal, lamb and mutton and turkeys are projected to increase for both series E and E' while the production of chickens, eggs and milk are projected to decrease for this same time frame. The acres required to meet these OBERS projections are shown in table IV-7.

As a third level projection, the agriculture ad hoc group related crop requirements to OBERS projected livestock production. These requirements are expressed in feed units (one feed unit is the feed value of one pound of No. 2 corn or its equivalent) and the feed unit needs are shown for each livestock product type. In addition, ration compositions by roughage feed grains and protein supplement are expressed as percentages of total feed units.

Table IV-8 summarizes the exeess or deficit of feed units for the North Dakota planning area by roughage and grain categories. A minus sign (-) indicates that the OBERS roughage or grain projection was not adequate under the assumed conditions for meeting the comparable OBERS livestock production projection.

Table IV-4. Number of Head of Livestock, North Dakota Tributaries 1/

Livestock	Unit	1949	1954	1959	1964	1969	Base
All Cattle & Calves	#	492,680	673,531	617,492	810,743	735,252	1,013,000
Milk Cows	#	80,379	76,144	63,381	59,610	41,533	40,500
All Sheep & Lambs	#	79,489	144,837	184,308	152,234	131,293	69,500
All Hogs & Pigs	#	75,250	125,671	112,123	74,727	68,058	75,000
Chickens 4 Months & Older	#	607,813	810,943	583,388	399,190	182,114	182,114 2/
Horses & Ponies	#		27,234			13,392	13,392 2/

1/ Source of data is U.S. Agricultural Census for years 1949 through 1969. The "base" is 1974 data from Statistical Reporting Service.
2/ Agricultural Census for 1969 is most current county estimate available.

Table IV-5. Projected Crop Production for 1985 and 2000, North Dakota Tributaries

Crop	Unit	Base1/	Series E		Series E'	
			1985	2000	1985	2000
Wheat	Bu.	40,584,300	38,546,111	44,714,508	44,714,508	53,675,260
Rye	Bu.	530,517	909,971	1,034,237	1,281,816	1,735,768
Corn for Grain	Bu.	128,333	80,413	18,386	70,013	98,059
Silage	Tons	538,670	779,129	830,699	844,001	952,744
Oats	Bu.	19,444,633	32,037,211	37,583,722	35,342,199	51,917,741
Barley	Bu.	10,156,533	13,653,007	16,776,063	15,329,374	19,906,016
Hay	Tons	1,406,033	1,595,485	1,914,121	1,764,862	2,256,426
Soybeans	Bu.	9,738 2/	11,348	14,252	15,447	32,558
Flaxseed	Bu.	525,900	1,042,820	916,615	1,180,974	1,097,765
Sugar Beets	Tons.	113,767	39,373	117,034	132,360	162,709
Irish Potatoes	Cwt.	183,100 2/	203,122	240,538	221,209	265,327
Dry Beans	Cwt.	25,394 2/	14,133	8,243	13,714	6,976

1/ 1972-1974 average unless noted otherwise.
2/ 1969 Agricultural Census.

Table IV-6. Projected Livestock Production for 1985 and 2000
North Dakota Tributaries

Livestock	Unit	Base 1/	Series E		Series E'	
			1985	2000	1985	2000
			Thousands			
Beef and Veal	Lbs.	381,849	407,165	552,338	420,876	593,760
Pork	Lbs.	26,118	26,042	21,679	24,832	21,738
Lamb and Mutton	Lbs.	5,232	7,725	8,687	3,077	3,047
Chickens	Lbs.	672	639	287	704	317
Turkeys	Lbs.	360.4 2/	583.2	502.7	595.3	568.9
Eggs	Doz.	2,449	3,377	1,518	2,870	1,529
Milk	Lbs.	190,336 3/	171,276	137,731	187,267	140,142

1/ Base is 1974 unless otherwise noted.
2/ 1969 percent of state production times 1974 state production.
3/ Estimate is from North Dakota State Department of Agriculture for commercial market from July 1, 1972 to June 30, 1973.

Table IV-7. Acres Required to Meet OBERS Projections
Using "Future Without Plan" Projected Yields
North Dakota Tributaries

Crop	E				E'			
	1985		2000		1985		2000	
	Nonirr.	Irr.	Nonirr.	Irr.	Nonirr.	Irr.	Nonirr.	Irr.
Wheat	1,308,685	11,885	1,361,056	20,727	1,506,028	13,677	1,633,811	24,880
Rye	25,277	-	25,856	-	35,606	-	43,394	-
Corn for Grain	1,323	196	232	57	1,152	170	1,235	305
Silage	132,817	10,305	92,574	11,911	143,876	11,163	106,175	13,661
Oats	588,138	4,146	628,465	6,990	648,810	4,574	868,178	9,656
Barley	274,913	2,497	303,954	4,316	308,668	2,803	360,664	5,121
Hay	1,145,624	52,727	1,209,350	92,426	1,267,244	58,325	1,425,612	108,954
Flaxseed	83,480	2,053	61,885	2,511	94,540	2,325	74,115	3,008
Sugar Beets	-	4,062	-	4,876	-	6,016	-	6,780
Irish Potatoes	1,103	183	1,119	308	1,200	200	1,234	340
Dry Beans	700	179	322	137	679	174	273	116
Subtotal	3,562,060	88,233	3,684,813	144,259	4,007,803	99,427	4,514,691	172,821
Irr. Pasture	-	2,420	-	3,957	-	2,728	-	4,741
Total	3,562,060	90,653	3,684,813	148,216	4,007,803	102,155	4,514,691	177,562

Table IV-8. Livestock Feed Units Produced and Consumed
OBERS Projections, North Dakota Tributaries

Year	Feed Units Produced		Feed Units Required		Excess or Deficit Feed Units		
	Roughage	Grains	Roughage	Grains	Roughage	Grains	Total
				Thousands			
1985 Series E	5,542,594	1,520,662	5,271,718	622,487	270,876	898,175	1,169,051
2000 Series E	6,095,580	1,812,299	7,075,969	753,219	-980,389	1,059,080	78,691
1985 Series E'	5,786,104	1,688,012	5,404,999	631,309	381,105	1,056,703	1,437,808
2000 Series E'	6,580,822	2,367,064	7,539,045	792,388	-958,223	1,574,676	616,453

It was assumed in this high projection that the study area would continue to produce livestock with feed rations similar to those used now, i.e., predominately roughage. With that assumption, then the excess feed units from feed grains are not utilized.

The 958,223,000 roughage feed unit deficiency was then converted to acres required. To accomplish this it was assumed that the roughage deficit might be met with irrigated alfalfa hay which contains about 1,100 feed units per ton. Irrigated hay yields were projected by the agricultural ad hoc work group to increase to an average of 3.7 tons per acre by 2000. The production of 958 plus million feed units with alfalfa hay at the 3.7 tons per acre would require 235,435 acres of land. Those 235,435 acres would be in addition to the 177,560 acres already shown for E' so a total of 412,995 acres would be needed.

Whether or not the study area can or should provide the necessary feed for the projected livestock level is a matter for conjecture. North Dakota exhibited rapid growth in the cattle industry over the historical time period (table IV-4) used for developing the State projections. As a consequence, the State's share of national cattle production was projected to continue to increase. Without major shifts in cropping patterns and livestock production methods, it appears doubtful that the study area can sustain the historic growth pattern in the livestock sectors. Nevertheless, use of these livestock projections as determinants of crop needs does provide a valid high level for consideration in the planning process.

The acres required to meet these OBERS projected crop and livestock projected yields are shown in table IV-9. For the Series E projections a total of 90,653 acres of irrigated lands is required by 1985 increasing to a total of 148,216 acres by the year 2000. With the series E' projections this requirement for irrigated acres would increase to a total of 102,155 irrigated acres by 1985 and 177,562 irrigated acres by the year 2000. For the E' "high" projections the requirement for irrigated acres would be 102,155 acres in 1985 and 412,995 acres by the year 2000.

Table IV-9. Three Levels of Irrigated Land Requirements for North Dakota Tributaries

Year	E (Low)	E' (Medium) Acres	3rd (High) 1/
1975	56,000	56,000	56,000
1985	90,650	102,155	102,155
2000	148,215	177,560	412,995

1/ Based on Series E' crop and livestock projected needs for the area. In the year 1985, feed grain and roughage needs and livestock needs in the area as shown by OBERS E' balance; however, in 2000 roughage needs of livestock far exceed OBERS E' roughage projections. The 2000 figure assumes those roughage needs may be met by irrigated hay production. See the Agricultural Ad Hoc Work Group Supplemental Report on the Third Projections for detail on needed feed units.

Instream Flow[19]

North Dakota century code (61-01-01.1) established the priority for water as first in time, first in use. In the case of competing applications the permits are issued by the following order of priority:

1. domestic;
2. municipal;
3. livestock;
4. irrigation;
5. industrial; and
6. fish, wildlife and other outdoor recreational uses.

In the study area in North Dakota several water right permits have been issued for fish, wildlife, and stockwater purposes. In addition permits have been issued for fish, wildlife and recreational purposes. The largest permit applications is in conjuntion with the following projects; Spring Creek, Crown Butte, Fish Creek, Sweetbriar, Cedar Creek, Sheep Creek, and Indian Creek, all located on tributary creeks to the western Dakota tributary streams. The existing appropriations for fish and wildlife use within the North Dakota portions of the study area total approximately 25,000 acre feet of storage and 10,000 acre-feet of annual use, these do include use for stockwater purposes but do not include instream flow per se.

Instream Flow Methodologies - In the Northern Great Plains Resource Program, instream flow needs were defined "as the minimum amounts of water required in a stream (seasonably) to maintain essentially the existing aquatic resources and associated wildlife and riparian habitat." Some of the basic assumptions in the methodology used under this approach were;

1. The amounts of water flowing past a gaging station represented the flows supporting present levels of aquatic and related resources.

19/ See Instream Flow Study Needs, Yellowstone Study Area, August 1975.

2. Water quality would remain relatively unchanged.
3. The natural hydrologic cycle or pattern of flow should be maintained.
4. The 10 percentile flow or in other words the flow exceeded 90 percent of the time was considered as the initial estimate of instream flow need.

A four-step methodology was developed to estimate the instream needs of average hydrological conditions as follows:

1. Based on hydrologic stream flow data, the average monthly flow for three conditions; representing 1) dry, 2) average, and 3) wet years were determined.
2. The 10 percentile flow was determined.
3. The instream estimates above were adjusted on quantities of water entering or leaving the stream system.
4. Estimates were modified based on specific species requirements.

Deviations from this methodology were as follows:

1. For stream reaches involving natural trout habitat, a 50 percent percentile flow requirement based on average daily flows was used.
2. For the Powder River and Western Dakota tributaries where large variations in flow are "normal" the percentile flow selected was varied for those months in which the monthly flow averaged less than 10 percent, from 10 to 50 percent, and 50 to 100 percent, for those months exceeding 100 percent of the mean monthly flow.

Other methodologies for estimating instream flow needs have been used in various studies conducted by State and Federal agencies.

For the streams in the North Dakota study area, the instream flows for the 90 percent exceedance level are shown in table IV-10. The modified flow for these streams as determined using the above criteria are shown in table IV-11.

Table IV-10. Instream Water (cfs) for Selected Rivers in North Dakota, 90% Exceedance Level

Stream and Location	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
North Fork Grand River at Haley, N.D.	0	0	1	2	1	1	1	0	0	0	0	0
Cannonball River at Regent, N.D.	1	0	5	7	4	6	2	1	2	2	2	2
Below Bentley, N.D.	1	1	7	16	9	12	5	4	3	5	6	4
At Breien, N.D.	0	0	22	60	24	21	6	13	1	1	3	2
Cedar Creek near Haynes, N.D. (Tributary)	1	1	2	4	2	1	0	0	0	1	1	1
Cedar Creek near Pretty Rock, N.D. (Tributary)	0	0	0	5	5	3	2	0	0	0	2	2
Cedar Creek near Raleigh, N.D. (Tributary)	0	0	0	13	7	36	12	0	0	0	0	0
Little Missouri River at Marmouth, N.D.	0	0	68	75	31	70	48	25	6	5	5	1
At Medora, N.D.	0	0	0	8	36	68	70	4	4	2	0	0
Near Watford City, N.D.	0	0	158	204	86	165	139	44	18	7	5	1
Knife River at Manning, N.D.	0	0	0	0	0	0	0	0	1	1	1	1
Near Golden Valley, N.D.	0	0	0	12	9	9	8	2	2	1	4	4
At Hazen, N.D.	3	1	14	56	21	17	18	9	13	17	15	10

Table IV-10. Instream Water (cfs) for Selected Rivers in North Dakota, 90% Exceedance Level (Continued)

Stream and Location	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Heart River												
below Dickinson Dam, near Dickinson, N.D.	0	0	0	0	0	1	0	0	0	0	0	0
Near Richardton, N.D.	0	0	2	18	7	15	5	1	0	3	3	3
Below Heart Butte Dam near Glen Ullin, N.D.	3	2	3	0	6	37	37	33	23	13	13	6
Near Lark, N.D.	1	0	16	36	18	49	36	42	31	30	19	11
Near Mandan, N.D.	0	0	0	65	35	40	39	31	16	23	16	11
Green River near Gladstone, N.D. (Tributary)	1	0	6	7	2	2	2	0	0	1	2	2

Table IV-11. Instream Water (cfs) for Selected Rivers in North Dakota, Modified Level

Stream and Location	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
North Fork Grand River at Haley, N.D.	1	2	45	29	19	35	4	1	1	1	1	1
Cannonball River at Regent, N.D.	1	5	45	20	20	44	14	6	4	1	3	3
Below Bently, N.D.	4	15	121	45	47	78	24	11	9	7	9	6
at Breien, N.D.	6	39	313	233	129	236	90	25	15	16	18	11
Cedar Creek near Haynes, N.D. (Tributary)	2	4	33	26	24	51	14	8	2	2	3	2
Cedar Creek near Pretty Rock, N.D. (Tributary)	2	14	91	72	28	61	22	7	3	2	3	3
Cedar Creek near Raleigh, N.D. (Tributary)	1	8	95	62	114	96	34	7	9	2	2	3
Little Missouri River at Marmarth, N.D.	4	160	445	250	196	360	137	47	25	33	20	7
at Medora, N.D.	2	75	528	370	300	400	180	64	30	29	18	7
near Watford City, N.D.	1	187	939	497	299	583	270	122	59	68	28	8
Knife River at Manning, N.D.	1	6	44	55	19	28	21	3	6	2	2	2
near Golden Valley, N.D.	6	27	190	138	54	83	31	14	7	7	9	6

Table IV-11. Instream Water (cfs) for Selected Rivers in North Dakota, (cont'd)
Modified Level

Stream and Location	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Knife River												
at Hazen, N.D.	16	51	316	222	53	167	73	28	25	26	27	19
Spring Creek near Zap, N.D. (tributary)	3	13	69	63	22	28	14	5	7	7	7	5
Heart River												
near South Heart, N.D.	1	8	56	25	20	27	5	6	1	1	1	1
below Dickinson Dam, near Dickinson, N.D.	1	1	35	30	14	31	12	6	2	1	1	1
near Richardton, N.D.	3	15	180	97	53	78	42	9	8	6	7	6
below Heart Butte Dam near Glen Ullin,N.D.	23	16	62	157	50	62	67	55	54	47	34	26
near Lark, N.D.	19	23	230	186	57	139	81	67	32	49	39	28
near Mandan, N.D.	13	23	283	243	71	165	96	77	65	55	42	25
Green River near New Hradec, N.D. (tributary)	1	1	42	43	12	11	12	1	1	1	1	1
Green River near Gladstone, N.D. (tributary)	2	7	73	58	13	25	21	4	3	3	4	3

Municipal and Rural Domestic Water[20/]

The ad hoc committee for this task provided unit water requirements for municipal and related industrial demands, rural domestic demands and other nonenergy related industrial water requirements. The projected water requirements for the North Dakota Study Area as shown in table IV-12 were based on the projected populations provided by the population ad hoc work group.

Table IV-12. Rural, Domestic and Municipal Water Requirements

Yellowstone Level B Study Area

	Projected Population	Water Use (acre-feet)	Increase Above Current (acre-feet)
Current	97,970	20,300*	-
Projected - 1985			
Most Probable	119,060	24,700	4,400
Extensive	131,150	27,200	6,900
Projected - 2000			
Most Probable	161,450	33,500	13,200
Extensive	166,520	34,500	14,200

* In addition, livestock water use was estimated at 19,000 acre-feet.

Communities in rural areas will rely mainly on ground water for their water supplies. As projected population increases will be centered in populated areas, more individuals will be served by surface water supplies because the large communities obtain their water supplies from surface water sources. During the course of the study, a water source was not determined for the population projections; however, it was assumed that municipal wells would provide 35 percent, private wells 35 percent, and surface water 30 percent of the water requirements.

20/ Letter report by Municipal and Rural Domestic Ad Hoc Group, April 21, 1977.

Flood Control and Streambank Erosion[21/]

Two ad hoc committees, one for drainage areas in excess of 400 square miles headed by the Crops of Engineers and one for drainage areas of less than 400 square miles headed by the Soil Conservation Service prepared reports on flood control and erosion requirements.

Streambank erosion damages of a moderate to serious nature are estimated to affect 278 bank miles along the Western Dakota Tributary streams and 18 miles along the Yellowstone River within North Dakota. Average annual damages are projected to increase from a present total of $39,300 to $55,000 by 1985 and $62,300 by the year 2000 (figure IV-1). Streambank erosion along mainstem reaches of the Little Missouri, Knife, Heart and Cannonball Rivers is estimated to occur along 362 bank miles. Of this 38 miles are estimated to be a serious erosion problem. Average annual damages are estimated to increase from a present total of $265,000 to $369,000 by 1985 and to $419,000 by the year 2000 (figure IV-2).

Flood damages which might occur under existing conditions along the tributary stream reaches were classified in three general categories (1) crop and pasture, (2) other rural and (3) urban. Average annual damages were projected for tributary reaches with less than 400 square miles drainage area (figure IV-3). Of the total $1,337,000 figure estimated for 1975 only $64,000 was attributed to urban damages. Average annual flood damages along mainstem reaches are shown in figure IV-4. Of the total damages of $1,075,000 shown for 1975, $307,000 occur in urban areas, the remainder is the result of flooding in terms of crop, pasture and other rural damages. The total of both main stem and tributary flood and streambank erosion damages was $2,716,000 in 1975 of which 13.7 percent is urban damages. Total average annual damages from both mainstem and tributary flooding and streambank erosion is

21/ See Flood Damages and Streambank Erosion Damages Along Mainstem Reaches, Corps of Engineers, Missouri River Division, May 1976 and Flood Control and Streambank Erosion Needs, Drainage Areas Less than 400 square miles, Soil Conservation Service, Casper, Wyoming; August 1976

Figure IV-1 NORTH DAKOTA PLANNING AREA
STREAMBANK EROSION DAMAGES ALONG TRIBUTARY STREAM REACHES

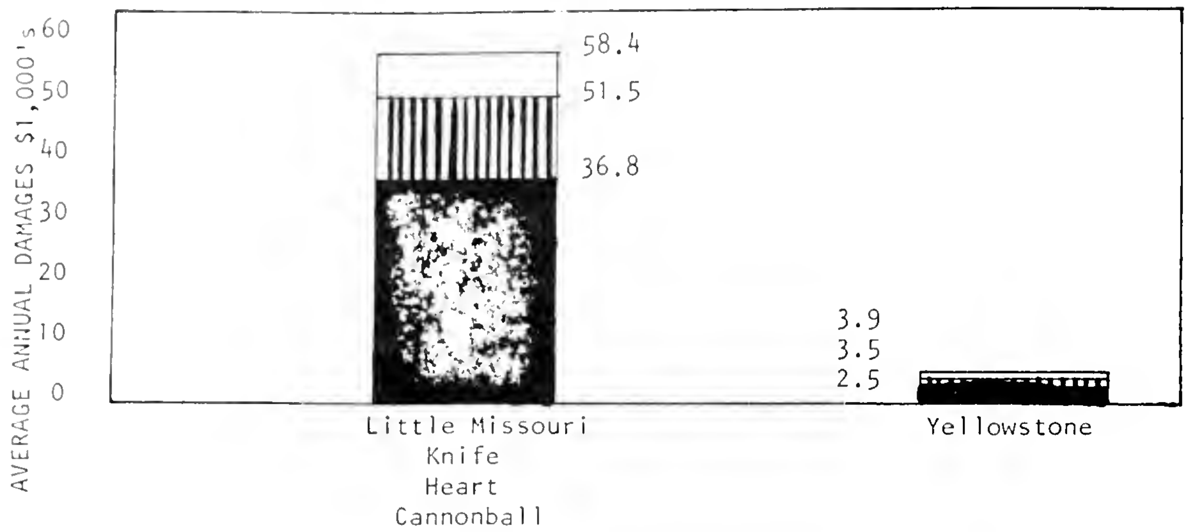


Figure IV-2 NORTH DAKOTA PLANNING AREA
STREAMBANK EROSION DAMAGES ALONG MAIN STEM REACHES

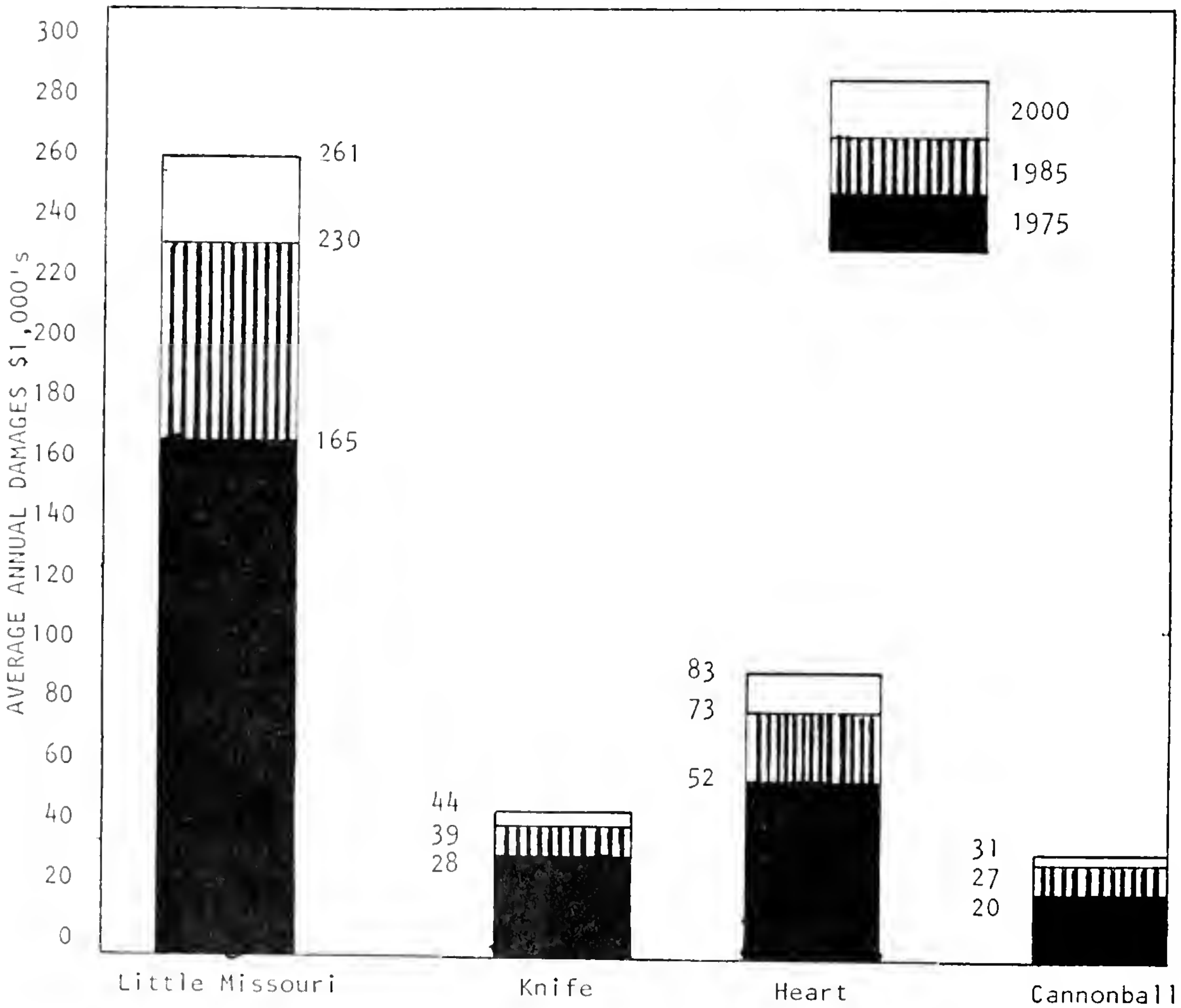


Figure IV-3 NORTH DAKOTA PLANNING AREA
CURRENT AND PROJECTED FLOOD DAMAGES ALONG TRIBUTARY REACHES
LESS THAN 400 SQUARE MILES

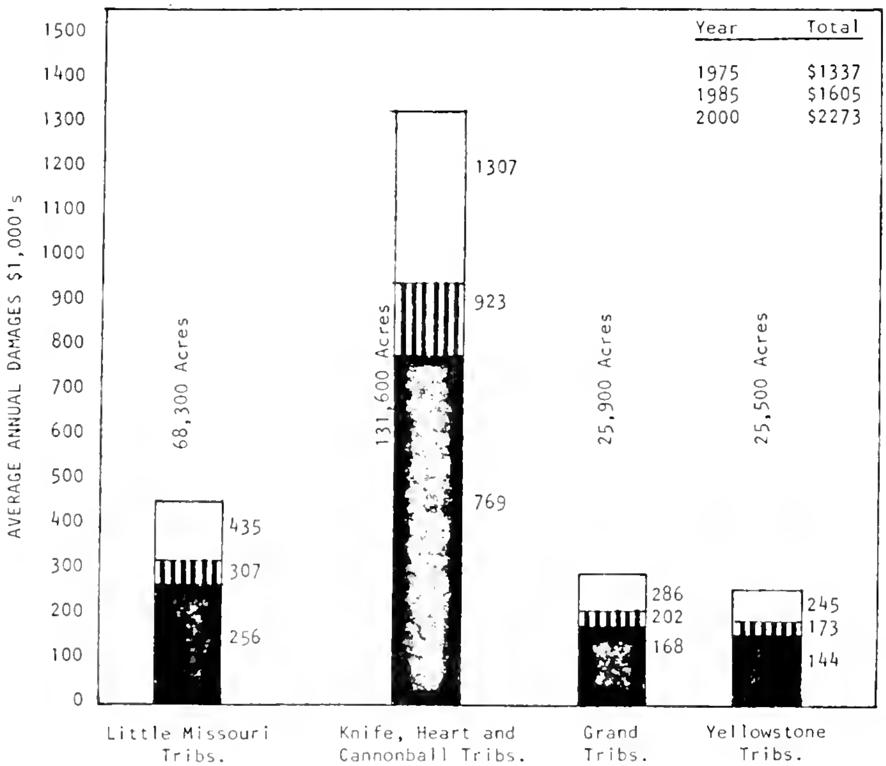


Figure IV-4 NORTH DAKOTA PLANNING AREA
CURRENT AND PROJECTED FLOOD DAMAGES ALONG MAIN STEM REACHES

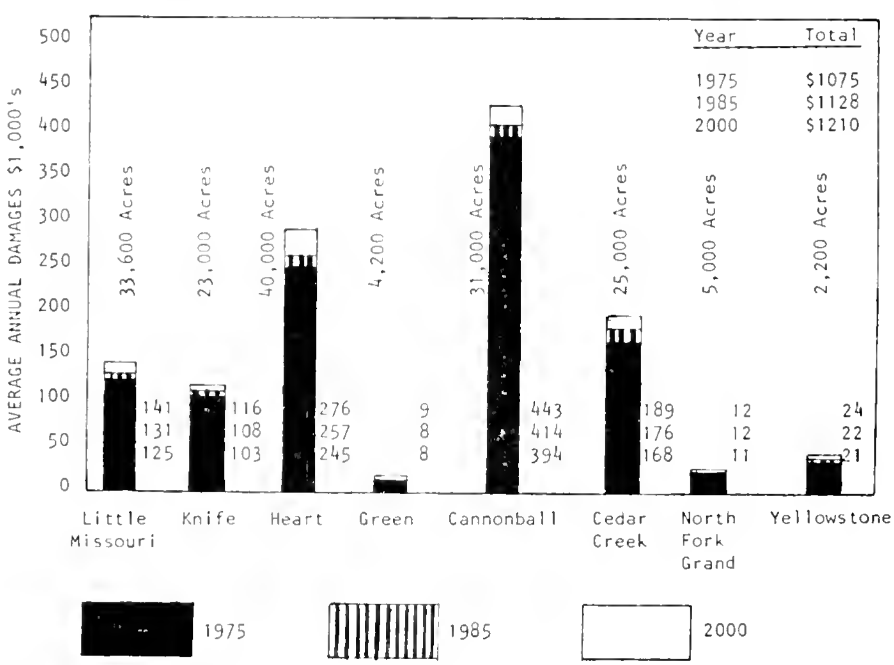
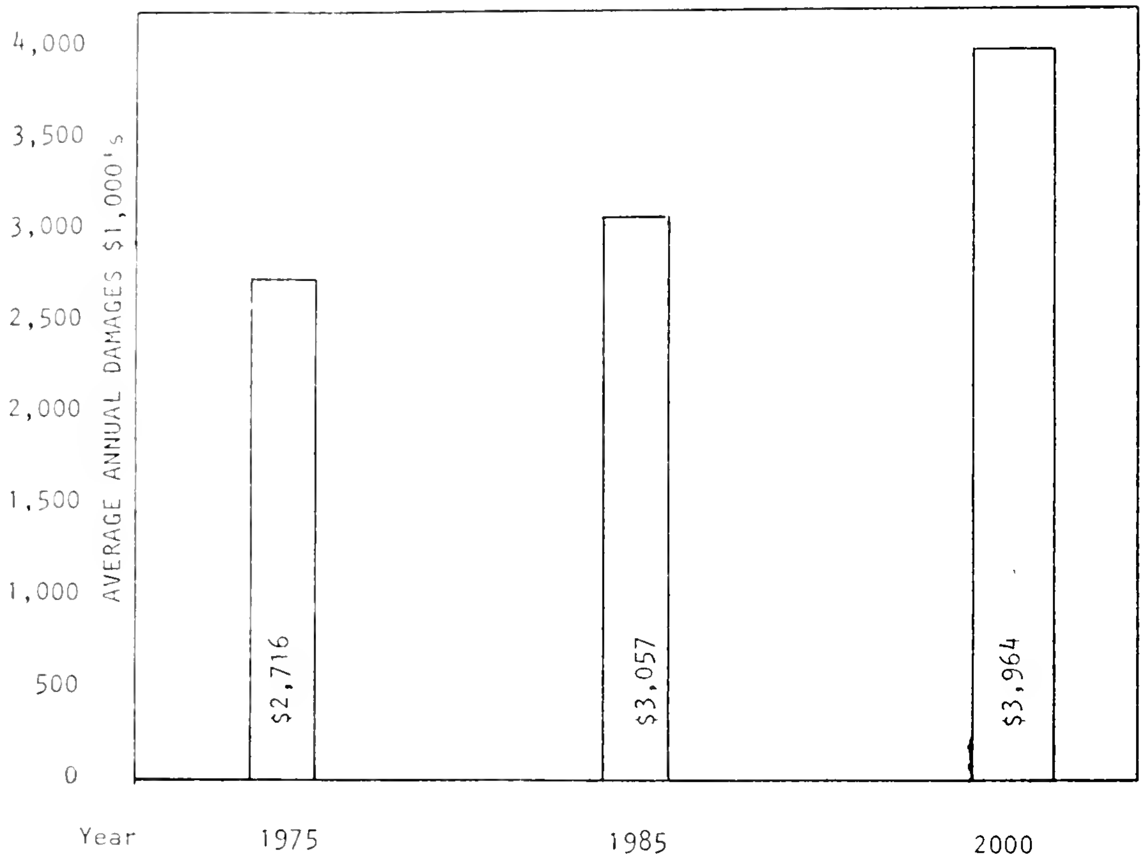


Figure IV-5 NORTH DAKOTA PLANNING AREA
TOTAL CURRENT AND PROJECTED FLOOD AND STREAMBANK EROSION DAMAGES ALONG TRIBUTARY AND MAIN STEM REACHES OF THE LITTLE MISSOURI, KNIFE, HEART, CANNONBALL, GRAND AND YELLOWSTONE RIVERS IN NORTH DAKOTA FOR THE YEARS 1975, 1985 AND 2000



projected to increase to $3,057,000 by 1985 and $3,964,000 by the year 2000 (figure IV-5).

Land Conservation Measures 22/

The objective of installing land conservation measures is to make wise use of soil, water, and plant resources within their capabilities and also provide treatment according to need so as to preserve, maintain, and enhance resource values. Land conservation is achieved by controlling or ameliorating the forces that affect the resources. These forces include natural forces, such as water, wind, fire, and climate, and cultural forces, such as farming, mining, grazing and other land uses. Measures that protect the land from these natural and cultural forces affect both yield and quality of water and the productivity of the land.

Historic Development of Land Use - The fur trade was almost the sole commercial use of the vast natural resources in the Yellowstone Basin and Adjacent Area during the period from 1806 to 1850. About 1880 it was realized that the area offered excellent ranching possibilities, and within the next few years it was completely stocked with cattle. The first sheep were brought into the area about 1876.

Early development of cultivation was made under the Homestead Act of 1862 and the Desert Land Act of 1877 which initially limited settlement to 160 and 640 acres, respectively. The first diversions of water for irrigation were made about 1883. Passage of the Carey Act in 1894 added impetus and organization to irrigation development.

Under the Reclamation Act of 1902, the Federal Government undertook the development of public irrigation systems, including storage facilities. The Stock Raising Homestead Act of 1916 provided for the settlement of nontillable grazing land. Beginning about 1880, cattle and sheep were grazed on the "free" or cheap range with little regard for proper grazing capacity. The severe overloading of the ranges on

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22/ See Level B Study, Land Conservation Measures, BIA, BLM, FS, SCS, State of Montana, State of North Dakota, State of Wyoming, February 1977.

poor soils with low, undependable rainfall had an adverse effect on the native vegetation. Density of plants was severely reduced, and many of the most desirable species became nearly extinct. An increase in big game numbers resulted from their protection by law and added to grazing the overload on the range.

Although the Organic Act of 1897 provided for some control of the range use of the public domain, it was not until the 1930's that strict control measures were actually enforced on Federal lands. The Taylor Grazing Act, the Indian Reorganization Act of 1934, and the Soil Conservation Act of 1935 added emphasis to the proper use concept on both federally-owned and private lands. Range improvement and soil and moisture conservation programs were initiated in an attempt to repair the damage caused by over 50 years of uncontrolled grazing. Started in 1933 the Civilian Conservation Corps provided some of the first structural works in soil and water conservation.

An acute awareness of the need for conservation of our basic resources -- soil and water -- has led to the development and implementation of many conservation programs since 1940. Primary among these are conservation farming techniques and improved forest and range management practices, with more extensive application and better enforcement of these practices. The Multiple Use-Sustained Yield Act of 1960 for National Forest Lands and the Federal Land Policy and Management Act of 1976 for the Public Domain Lands have added impetus to land conservation by insuring that conservation values would not be sacrificed to enhance other resources.

Effects of Land Conservation - Land conservation measures preserve and improve the land, water, and plant resources. Measures specifically designed to control wind and water erosion will also contribute to the reduction of flood hazards in rural and urban areas, improve water disposal in needed areas, and generally enhance recreational and fish and wildlife values. While measures may vary from one area to another, the long-term result common to nearly all measures is that of sustained or increased production. Land conservation measures, such as improved irrigation systems, would decrease diversion water requirements. The additional water sal-

vaged by improved efficiency could be used to supplement the supply for existing irrigated lands or bring new acres into production or for non-development purposes such as instream flow for fish and wildlife or improving water quality.

Improved management of forest land will reduce snow and rainfall evaporation from dense forest canopy. Proper thinning and harvest will allow snowmelt and rainfall to accumulate as ground water and runoff.

A recent comprehensive study in the Platte River Basin in Nebraska illustrated that sediment delivery could be expected to decrease by 7 percent for each 10 percent of land adequately treated[23/]. The draft of the National Commission on Water Quality report estimates that if land conservation measures were applied to all farmland nationally, the result would be a 50 percent reduction in stream sediment loads, as well as an accompanying reduction in such related pollutants as nutrients and pesticides.

A frail lands study conducted by the Agricultural Research Service in northeastern Montana indicated that contour furrowing increased available soil water in the 0 to 24 inch profile. Over a 7-year period the days of available soil water increased from 35-100 percent on various sites. The increased water on the contour furrowed treatments resulted from both a decrease in runoff and an increase in snow catch.

Current Status and Projected Requirements - The current status of land conservation in the North Dakota Tribs Planning Area is that 8,169,640 acres (59 percent) of the land within the planning area are adequately treated. This includes 1,142,140 acres located on federal lands and 7,027,500 acres on non-Federal lands.

In determining the projected requirements for land conservation, it has been assumed that this is all land not now classified as adequately treated. For this reason, the projected requirements are the same for both 1985 and 2000. As of

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23/ Land adequately treated -- Land on which the conservation measures essential to its sustained use have been applied.

1975, it was estimated that 5,771,600 acres still needed the application of some land conservation measures before they could be considered as adequately treated. The total estimated cost to install this treatment is $170,614,000.

A breakdown of the area needing treatment by land use and ownership is shown in table IV-13.

Fish and Wildlife 24/

There are 10 national wildlife management areas (refuges) within the planning area: 1 each in Dunn and Grant Counties, 2 in Slope County, and 6 in McLean County. In addition approximately 20,000 acres of "waterfowl protection areas" exist in McLean County. The number of acres of easement lands and lands acquired for fee title for each refuge, and the total easement and fee lands for "waterfowl protection areas" are shown in table IV-14. Although there are additional lands adjacent to some of the existing wildlife and/or waterfowl areas that may have potential for addition to the refuge or production area system, projections for needs were not quantified under this study.

Outdoor Recreation 25/

The existing recreation supply was based on the inventory completed in 1974 by the SCS and updated to mid-1976 conditions. These existing recreation areas were classified into three major type areas, 1) type I areas (historic, scenic and natural), 2) type II areas (land-oriented recreation) and 3) type III areas (water-oriented recreation). For a detailed description of these areas the reader is referred to the outdoor recreation ad hoc group report.

The existing supply and projected demand within the North Dakota planning area for nine recreation activities are shown in table IV-15.

24/ See Short Status Reports for Endangered Species and Migratory Birds North Dakota, Fish and Wildlife Ad Hoc Group, December 6, 1976.

25/ See Outdoor Recreation Ad Hoc Group Report, April 1977.

Table IV-13. Projected Land Conservation Requirements by Major Land Use and Ownership, North Dakota Tributaries

Land Use and Ownership	Acres	Dollars
Non-irrigated Cropland	2,727,000	149,997,000
Federal	0	0
Non-federal	2,727,000	149,997,000
Irrigated Cropland	28,100	3,244,000
Federal	0	0
Non-federal	28,100	3,244,000
Non-irrigated Pasture	141,300	3,180,000
Federal	0	0
Non-federal	141,300	3,180,000
Irrigated Pasture	0	0
Federal	0	0
Non-federal	0	0
Range	2,861,200	14,134,000
Federal	446,700	5,054,000
Non-federal	2,414,500	9,080,000
Forest Comercial	8,400	21,000
Federal	0	0
Non-federal	8,400	21,000
Forest-Non-Commercial	5,400	38,000
Federal	0	0
Non-federal	5,400	38,000
Other	0	0
Federal	0	0
Non-federal	0	0
Total	5,771,600	170,614,000
Federal	446,700	5,054,000
Non-federal	5,324,900	165,560,000

Table IV-14. National Wildlife Refuges and Waterfowl Protection Areas, North Dakota Tributaries

National Wildlife Refuges	Easement - Acres	Fee - Acres
Dunn County		
Lake Ilo 1/	3,194	838
Grant County		
Pretty Rock	1,140	---
McLean County		
Audubon 2/		14,776
Camp Lake	586	
Hiddenwood Lake	368	
Lake Nettie 1/	634	2,261
Lost Lake	960	
McLean 1/	416	334
Slope County		
Stewart Lake	2,226	4
White Lake		1,040
Waterfowl Protection Areas	Easement Wetland Acres	Fee - Acres
McLean County	16,561	3,148 3/

1/ Acquisition not completed

2/ Owned by Corps of Engineers, managed by FWS

3/ Acquisition continues on new areas and in rounding out other areas

Table IV-15. Outdoor Recreation Supply and Demand, North Dakota Tributaries 2/

Activity	Activity 1/ Occasion Unit	Existing Supply	Demand					
			Base Population		Most Probable		High	
			1985	2000	1985	2000	1985	2000
Beach Swimming	Beaches	25	43	54	50	79	55	82
Water Skiing	Acres	236,115	3,798	5,794	4,375	8,503	4,822	8,770
Picnicking	Acres	815	181	216	209	317	230	327
Nature Walks	Miles	NA	239	351	330	515	364	532
Boating/Canoeing	Acres	236,146	6,691	3,491	3,496	5,094	3,852	5,254
Camping	Acres	1,207	782	914	902	1,341	993	1,387
Hiking	Miles	176	67	90	77	133	85	137
Playing Games/Sports	Acres	1,754	179	253	207	371	228	383
Winter Sports	Acres	1,101,309	26	31	30	45	33	47

1/ Units as indicated are synonomous with total requirements.

2/ Source, Outdoor Recreation Ad Hoc Group Report, April 1977.

Population, Income and Employment[26/]

Baseline population projections for the North Dakota tributaries are from North Dakota County population projections[27/]. Sector earnings shown in table IV-16 for the base time period are 1974 estimates. The 1974 figures were indexed to 1975 dollar basis using the personal consumption expenditure index extimated by the Bureau of Economic Analysis, U.S. Department of Commerce. The 1985 and 2000 earnings figures are also expressed in 1975 dollars.

The energy study (reference 17) provided the base for coal related employment and population estimates, however, in addition to the operating employment included in that report it was important to estimate operating employment for average transportation facilities and construction employment for mines, gas plants, electric plants and transportation facilities. The methods used for estimating and allocating coal related employment are shown in reference 27. Employment and population impacts for the North Dakota tributaries for the most probable and high energy levels are shown in table IV-17.

Nonenergy Minerals[28/]

Sand and gravel production has dominated nonenergy mineral production in the North Dakota planning area. Through the 1960-75 period, sand and gravel production accounted for 82 percent of the output value. Of this production, 82 percent was employed in roadbuilding. In the absence of more definitive indicators, the average sand and gravel output of 0.7 million tons during 1972-75 has been projected for the 1985 output level. For projecting the year 2000 level, the 2.8 percent national annual growth rate projected by the U.S. Bureau of Mines for sand and gravel has been accrued to the 1985 figure of 0.7 million tons. This results in a level

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26/ See Current and Projected Population, Income and Earnings, Report of Ad Hoc Work Group on Projections, Yellowstone River Basin and Adjacent Coal Areas, Level B Study.

27/ Ludtke, Richard L., North Dakota County Population Projections; 1975-1995, Division of Health Planning of the North Dakota State Department of Health, February 15,1976.

28/ See Non-Energy Mineral Industry Water Needs, Yellowstone River Basin Study Area, 1985 and Year 2000, Ad Hoc Group on Updating Minerals Data, Feb. 1977.

Table IV-16. Population, Employment, Personal Income and Earnings North Dakota Tributaries[1/]

	Base[2/]	OBERS[3/] 1985	OBERS[3/] 2000
		Thousands	
Population, Midyear	98.9	92.5	88.5
Per Capita Income (1975 $)	4.8	6.3	9.8
Per Capita Income Relative (U.S. = 1.00)	0.82	0.77	0.80
Total Employment	43.4	35.6	35.9
Total Personal Income (1975 $)	472,886	585,102	869,737
Total Earnings (1975 $)	358,690	435,109	646,324
Agriculture & Forestry	135,202	98.406	126,680
Mining	7,592	16,546	20,682
Contract Construction	30,550	23,077	34,901
Manufacturing	17,826	20.900	34,255
Trans., Comm. & Public Utilities	22,472	33,528	48,474
Wholesale & Retail Trade	54,244	77,941	111,168
Finance, Insurance & Real Estate	7,030	14,805	24,560
Services	28,953	67,927	117,631
Federal Civilian Government	14,351	20,465	28,438
State & Local Government	30,137	57,911	93,070
Armed Forces	2,732	3,483	4,524
Unaccounted for	7.601	438	1,941

1/ Source Current and Projected Population, Income and Earnings, Ad Hoc Work Group Report, Yellowstone River Basin and Adjacent Coal Area, Level B Study.

2/ The base data including population is from Bureau of Economic Analysis (BEA), Dept. of Commerce, Regional Economics Information System for 1974, converted to 1975 dollars. The estimated population is somewhat different than shown in Table 1 since these estimates were from several sources.

3/ Total personal income and total earnings are weighted averages of per capita figures for WRSA's 1011 and 1013 times Series E population disaggregations. Total earnings were disaggregated by finding the percent of total earnings for each sector in WRSA's 1011 and 1013. These two were weighted - 2 for 1011 and 1 for 1013.

Table IV-17. Employment and Population Impacts of Most Probable and High Energy Levels for North Dakota Tributaries 1/

	Most Probable		High	
	1985	2000	1985	2000
Direct Yearly Employment 2/				
Coal Mines	135	2,035	870	3,080
Conversion	845	6,065	1,615	7,295
Transportation	95	205	90	230
Construction	2,485	3,035	3,575	1,845
Total Direct	3,550	11,340	6,150	12,450
Total Employment	7,880	25,855	13,655	28,260
Population Impact	15,760	51,450	27,850	56,520

1/ These numbers are based on direct employment estimates proveded by Harza Engineering Company for operation of mines and conversion facilities. Direct Employment Estimates for transportation and construction were made by the Yellowstone Level B staff. Total employment and population impacts are based on the Montana impacts since the areas are similar in nature.

2/ This is employment that is in addition to that which existed for these activities in 1975.

of about 1.1 million tons by the year 2000.

In the absence of any foreseeable major up-turning factors such as increased highway construction, stone output for 1985 has been projected at only 10,000 tons. Application of the 3.2 percent annual national growth rate estimated by the U.S. Bureau of Mines results in a year 2000 projection of 16,000 tons of output.

Examination of a 16-year trend in nonbentonitic clay enables a projection of 55,000 tons of clay output for both 1985 and the year 2000. While water is not used in the excavation of clay, these projections are the basis of estimating demand for water use in the making of bricks from part of the clay output.

Water requirements for nonenergy mineral production are shown in table IV-18. These water requirements are relatively insignificant as compared to the projected water requirements for the major uses, as for energy or agriculture.

Table IV-18. Estimated Non-Energy Mineral Industry Water Needs, North Dakota Tributaries 1985 and 2000

	1985		2000	
	New Water	Consumption	New Water	Consumption
		(acre-feet)		
Sand & Gravel	469	12	739	21
Stone	3	insig.	3	insig.
Nonbentonitic Clay1/	31	31	31	31
TOTAL	503	43	773	52

1/ Used in brick making plant.

Summary of Projected Water Requirements

The projected water requirements for the North Dakota tributaries area are summarized in table IV-19.

Table IV-19. Summary of Projected Water Requirements North Dakota Tributaries

	Projected Water Requirement Acre-Feet/Year	
	1985	2000
Energy Production 1/		
Mines	1082	3165
Reclamation	8060	23580
Syngas	9986	100828
Electrical Generation	85494	102015
Slurry Pipeline	11365	15191
Irrigation 2/	204310	825990
Instream Flow 3/		
North Fork Grand River at Haley, North Dakota	8536	8536
Cannonball River at Breien	68884	68884
Little Missouri near Watford City	186326	186326
Knife River At Hazen	62238	62238
Heart River near Mandan	70628	70628
Rural Domestic and Municipal 4/	6900	14200
Livestock 5/	19000	19000
Non-Energy Minerals 5/	43	52

1/ Based on high Harza projection (consumptive use).

2/ Based on a projected need for 102,155 acres by 1985 and 412,995 acres by the year 2000 with a diversion requirement of 2 acre-feet/acre. (Consumptive use would be lower depending on both crops producted and return flows).

3/ Based on the Northern Great Plains Resource Program modified flow level.

4/ Based on population increase from high level of coal development (consumptive use).

5/ Consumptive use.

CHAPTER V

WATER AND RELATED LAND RESOURCES
FUTURE WITHOUT PLAN AND THE
REMAINING NEEDS

Future Without - The Role of Private Enterprise

In the planning process used in this study, the next step after determining the theoretical requirements was to evaluate the resource capabilities and expected conditions of utilization or preservation without additional government involvement or interference. The divergence between the theoretical requirements for resources and what can be accomplished privately in their utilization is then assumed to be the remaining need. This chapter first projects the needs that are likely to be met by private enterprise and then identifies those remaining needs if any, as the role for government assistance.

Energy

Development of coal resources is expanding within the North Dakota portion of the study area. Existing thermal electric generating plants include a 172 MW United Power Association plant at Stanton, 652 MW Basin Electric Power Cooperative plant at Stanton, 234 MW Minnkota Power Cooperative plant at Center, 101 MW Montana Dakota Utilities plant at Mandan and a 14.9 MW Montana Dakota Utilities plant at Beulah. In addition, a 440 MW Minnesota Power and Light plant at Center and the first unit of a 900 MW United Power Association - Cooperative Power Association plant at Falkirk are presently under construction. Proposed thermal electric plants for which water permits have been approved include a 880 MW Basin Electric Power Cooperative plant at Beulah and a 440 MW joint venture plant at Beulah. A water permit for 17,000 AF for a 250 mcfd coal gasification plant proposed by American Natural Gas has been approved by the North Dakota State Water Commission. The company involved, however, has announced the first phase of this plant will consist of a 125 mcfd unit. A water permit for four 250 mcfd coal gasification plants in Dunn County proposed by the Natural Gas Pipeline Company was denied by the State

Water Commission. Coal mines supporting these conversion facilities are operated by Consolidation Coal Company, North American Coal Company, Baukol-Noonan, Knife River Coal Company, Falkirk Mining and Coteau Properties.

These projects are being developed or proposed by private enterprise; governmental controls are in the form of some coal leasing, land reclamation, emission requirements, water permits, plant siting laws and taxes.

A projection based on a high level of development that private enterprise could conceivably develop within the existing economic and governmental restrictions is shown in table V-1. This level of development represents the future without plan for energy development.

In this high level of coal development it was assumed that coal slurry pipelines would be allowed for which 11,365 AF of water would be needed by 1985 and 15,191 feet by the year 2000. Coal slurry pipelines would export 20 million tons of coal annually by 1985 and 26 million tons by the year 2000. A total generating capacity of 8870 MW would be operating within the North Dakota tributaries. In addition, 250 mcfd of syngas would be produced in 1985 and 2,524 mcfd by the year 2000. Coal production totals would be 54.1 and 158.26 million tons/year by 1985 and 2000, respectively. Total water requirements for mines, reclamation, coal gasification, electric generation, and slurry pipelines would total 115,987 AF/year by 1985 and 224,779 AF/year by the year 2000.

Agriculture

The first white settlers in the study area were the cattle ranchers who developed their herds from southern trail stock. Cattle numbers increased rapidly following the extermination of the buffalo in 1883. The first cattle boom was shortlived, as a drought beginning in 1886 halted the influx of cattle and the harsh winter of 1887 completely wiped out many of the larger herds. The lessons of climate were well learned and, for the most part, the farm-based livestock operation replaced the year-round use of range. Sheep ranching developed along with cattle ranching.

Table V-1. "Future Without" Energy Development Scenario
Estimated Resource Requirement[1/] and Air Pollutant Emissions

		1985	2000
Mines[2/]	Total Number	11	32
Coal Production	Million Tons/Year	54.1	158.26
Coal Gasification Plants[3/]	Number of Units	1	10
Production	MCFD	250	2,524
Thermal-Electric Plants[4/]	Total Number	18	18
Megawatt-Capacity	Megawatt	8,870	8,873
Generation	Gigawatt-Hr/Year	34,198	40,806
Water Requirements[5/]			
Mines	Acre-Feet/Year	1,082	3,165
Reclamation	" " "	8,060	23,580
Coal Gasification	" " "	9,986	100,828
Electric Generation	" " "	85,494	102,015
Slurry Pipeline	" " "	11,365	15,191
Total	" " "	115,987	224,779
Labor Requirements[6/]			
Mines	Man-Year/Year	1,091	3,300
Coal Gasification	" " "	624	6,302
Electric Generation	" " "	1,153	1,153
Total	" " "	2,868	10,735
Capital Requirements			
Mines	Million Dollars	224	775
Coal Gasification	" "	998	10,079
Electric Generation	" "	2,510	2,508
Total	" "	3,733	13,362
Land Requirements			
Strip Mining Area	Acres/Year	2,072	6,061
Sites			
Mines	Acres	1,623	4,748
Coal Gasification	"	499	5,042
Electric Generation	"	8,870	8,873
Total	"	10,992	18,663
Air Pollutant Emissions			
Particulates	Tons/Year	18,114	30,655
Sulfur Oxides	" "	216,331	357,363
Nitrogen Oxides	" "	178,435	279,211

1/ Assumed an adequate water supply can be delivered on a timely basis to the point of demand at a cost of less than $450 per acre-foot.
2/ Based on average mine capacity at 5 million tons per year.
3/ Based on average unit capacity at 250 MCFD.
4/ Based on average plant size at 500 megawatts.
5/ Consumptive use.
6/ Operating personnel only.

Through the filing of homestead entries on lands adjoining streams, the livestock industry adjusted to the farm livestock operation. Cattle and sheep grazed on the free range of the public domain without regard to carrying capacity until the passing of the Taylor Act in 1934.

Dryland farming began in the mid 1890's and developed slowly until high agricultural prices resulted from World War I. This prompted a rapid growth in dryland farming. Following the war, the boom ended forcing the abandonment of thousands of recently broken acres. Many acres of these abandoned lands were placed under cultivation every few years when rainfall was above normal and abandoned during the dry periods in between.

Drought was again prevalent throughout the area in the 1930's. Depression conditions brought low prices and drought brought poor crops, short feed and dry waterholes. People left, the land reverted to mortgage holders or to the county for back taxes. The Federal Government later purchased many acres of land under the Bankhead-Jones Act, maintaining and managing the rangelands which were submarginal ir size or quality.

The private enterprise sector has always played a major role in agricultural development in the study area. For example, private interests have historically developed about 75 percent of the new irrigation development in the area. This development is not without Federal help, however, for most of the SCS and ASCS programs were established to assist private persons and groups in their agricultural development.

Private enterprise also contributes greatly to increased production through improved management on the existing agricultural lands. Higher agricultural prices resulting from adverse weather and crop production, due in part to expanded foreign demand has caused a surge in new irrigation expansion in the past several years. Maintenance of continued and sustained agricultural production depends upon the

proper use and treatment of the land resource. Watershed protection measures to control wind and water erosion and contribute to the reduction of flood hazards are one way that private interests maintain crop yields.

The State of North Dakota does not at this time have an agricultural development program and because of this and the lack of a good quality ground water source, irrigated agriculture has been slow in developing within the planning area. While a total of 93,056 acres of land have State water permits it is estimated that only 56,000 acres of this are actually under irrigation at the present time (table V-2). This acreage includes all the existing irrigation projects developed by the Federal Government to date. However, for our purposes all present irrigation, including both government and private irrigation, is included in the 56,000 acre base estimate shown in table V-2. This acreage is projected to increase to 86,000 acres by 1985 and to 135,000 acres by 2000. This increase is projected as private development without additional governmental involvement, therefore it represents the future without plan. Total production for the present and future without plan for production is shown in table V-3 and for livestock production in table V-4.

Instream Flow

Instream flow is not presently recognized as a beneficial use in North Dakota and is outside of the private enterprise system. Under future without conditions it was assumed that other water uses would appropriate instream flows and the streamflows would continue to decline.

Municipal and Rural Domestic Water

Municipal water requirements have in the past been met by government programs and are likely to continue to be. Private enterprise has not developed water for sale in this area and because of the large distances and associated costs it is not likely to do so in the future. Rural water on the other hand is supplied through individual wells privately developed while livestock water is developed in many cases by private and governmental programs of the SCS. Projected water requirements for

municipal and rural domestic use above current (1975) conditions under the future without plan conditions are 6,900 AF in 1985 increasing to 14,200 AF by the year 2000.

Flood Control and Erosion

Projected damages from flooding within the planning area, are modest due to the population factor and the effects of current floodplain development and regulations. Flood control actions are traditionally a Federal Government program and as such flood control measures will not be affected by private enterprize. Soil erosion may be controlled, as it is now by individual farmers and ranchers with the continuance of Federal cost sharing programs.

Land Conservation

It is reasonable to assume that land conservation measures will continue to be installed in the future under without project condition. In an effort to make a projection of this condition, it is necessary to make an assumption that Federal funds will be made available to Federal agencies administering lands or programs at past historic rates. One can then assume that additional practices will be installed on Federal lands and that cost-sharing will be available as an incentive to install needed treatment measures on non-Federal lands.

It has been projected that an additional 1,115,200 acres will be treated in the planning area by 1985 and that this amount will increase to 2,162,400 acres by 2000. This includes 413,200 acres located on Federal lands and 1,749,200 acres on non-Federal lands.

A breakdown of the area expected to be treated by ongoing programs by land use and ownership is shown in table V-5. Additional details of the area projected to be treated by ongoing programs by land use and ownership are shown in tables V-6 and V-7 and figure V-1.

Fish and Wildlife

Requirements for fish and wildlife are met by habitat areas and private lands. Private enterprise may be encouraged by various governmental in-

Table V-2. Crop Yields per Harvested Acre, Crop and Production for Irrigated Lands - Present and Future Without Plan - North Dakota Tributaries

Crop	Yield & Prod. In:	Base1/ Acres	Base1/ Yield/Ac.	Base1/ Prod.	1985 2/ Acres	1985 2/ Yield Ac.	1985 2/ Prod.	2000 2/ Acres	2000 2/ Yield Ac.	2000 2/ Prod.
Wheat	Bu.	9,184	40	367,360	14,104	50	705,200	22,140	56	1,239,840
Corn for Grain	Bu.	324	73	23,652	499	93	46,407	783	107	83,781
Silage	Tons	4,587	15.6	71,557	7,043	17	119,731	11,055	20	221,100
Oats	Bu.	1,847	60	110,820	2,838	67	190,146	4,455	72	320,760
Barley	Bu.	1,437	65	93,405	2,210	73	161,330	3,470	84	291,480
Hay	Tons	29,744	3.0	89,232	45,676	3.1	141,593	71,700	3.7	265,290
Flaxseed	Bu.	799	14.0	11,186	1,230	20	24,600	1,930	20	38,600
Sugar Beets	Tons	6,087	19	113,767	9,348	22	205,656	14,675	24	352,200
Irish Potatoes	Cwt.	220	200	44,000	335	200	67,000	527	200	105,400
Dry Beans	Cwt.	279	18	5,022	430	32	13,760	675	32	21,600
Irr. Past. AUM's		1,492	5.3	7,908	2,288	5.3	12,126	3,590	5.3	19,027
Total Harvested		56,000			86,000			135,000		

1/ SRS does not report irrigated production by county in North Dakota. The base acres are from SCS estimates. Cropping pattern was determined by examining reports from USBR for Buford - Trenton, Fort Clark and Heart - Butte projects and North Dakota Irrigation Survey compiled by Darnell Lundstrom, NDSU. Base yields were estimated from 1972-1974 yields on the previously mentioned USBR projects and yields for Lower Yellowstone area of Montana.
2/ Projected acres from North Dakota State Water Commission. Projected yields based on Lower Yellowstone, Montana, since there is not an adequate data base in North Dakota. Cropping pattern for projected years is same as base year.

Table V-3. Total Production - Present and Future Without Plan - North Dakota Tributaries [1/]

Crop	Unit	Base	1985	2000
Wheat	Bu.	40,584,300	44,934,665	47,438,415
Rye	Bu.	530,517	604,687	635,994
Corn for Grain	Bu.	128,333	204,297	252,391
Silage	Tons	538,670	565,822	772,634
Oats	Bu.	19,444,633	23,174,284	24,091,975
Barley	Bu.	10,156,533	12,671,624	13,342,069
Hay	Tons	1,406,033	1,377,001	1,481,501
Flaxseed	Bu.	525,900	625,255	701,941
Sugar Beets	Tons	113,767	205,656	352,200
Irish Potatoes	Cwt.	183,100	371,359	408,769
Dry Beans	Cwt.	25,394	20,586	40,680

1/ Source Agriculture Ad Hoc Group Report

Table V-4. Livestock Production - Present and Future Without Plan - North Dakota Tributaries

Livestock	Unit	Base[1/] Production	1985 Production	2000 Production
Beef and Veal	000 Lbs.	381,849	438,187	480,653
Pork	000 Lbs.	26,118	22,638	19,800
Lamb and Mutton	000 Lbs.	5,232	4,461	3,597
Chickens	000 Lbs.	672	428	286
Turkeys	000 Lbs.	360.4	414	333
Eggs	000 Doz.	2,449	1,928	1,384
Milk	000 Lbs.	190,336	152,777	126,485

1/ See Table 5 for explanation of "base".

Table V-5. Ongoing Land Conservation Treatment, Projected to the Year 2000, North Dakota Tributaries

Land Use and Ownership	Acres	Dollars
Non-irrigated cropland	1,142,700	62,849,000
Federal	0	0
Non-federal	1,142,700	62,849,000
Irrigated cropland	6,600	762,000
Federal	0	0
Non-federal	6,600	762,000
Non-irrigated Pasture	29,200	656,000
Federal	0	0
Non-federal	29,200	656,000
Irrigated Pasture	0	0
Federal	0	0
Non-federal	0	0
Range	980,700	4,950,000
Federal	413,200	2,816,000
Non-federal	567,500	2,134,000
Forest-Commercial	2,000	5,000
Federal	0	0
Non-federal	2,000	5,000
Forest-Non-commercial	1,200	8,000
Federal	0	0
Non-federal	1,200	8,000
Other	0	0
Federal	0	0
Non-federal	0	0
Total	2,162,400	69,230,000
Federal	413,200	2,816,000
Non-federal	1,749,200	66,414,000

Table [illegible] Land Conservation on Non-Federal Land
Planning Area North Dakota Tribs. North Dakota

Land Use and Treatment Practice	Total Land (Acres)	1975 Treatment Status: Land Adequately Treated (Acres)	Land Needing Treatment (Acres)	Estimated Land Treatment [illegible]	1985: Treatment Completed w/ Ongoing Program (Acres)	Cost of Ongoing Program ($1,000)	Remaining Land Needing Treatment (Acres)	Remaining Land Treatment Costs ($1,000)	2000: Treatment Completed w/ Ongoing Program (Acres)	Cost of Ongoing Program ($1,000)	Remaining Land Needing Treatment (Acres)	Remaining Land Treatment Cost ($1,000)
Irrigated Cropland	[illegible]											
Management Only					[illegible]	[illegible]	[illegible]	[illegible]	6,600	76[illegible]	[illegible]	[illegible]
Management, Veg. & Mechanical			[illegible]		[illegible]	[illegible]	[illegible]	2,680	3,500	70[illegible]	11,400	[illegible]
Non-Irrigated Cropland	[illegible]											
Management Only					[illegible]	[illegible]	[illegible]	[illegible]4,[illegible]	[illegible]14[illegible],730	6[illegible],849	[illegible],584,[illegible]	[illegible]
Management, Veg. & Mechanical					4[illegible]	[illegible]	[illegible]	0	0	0	[illegible]	[illegible]
								[illegible]4,8[illegible]	1,14[illegible]	[illegible],849	[illegible],[illegible]84,[illegible]	[illegible],14
Irrigated Pasture												
Management Only												
Management, Veg. & Mechanical												
Non-Irrigated Pasture		[illegible]	[illegible]			[illegible]4	[illegible]	[illegible]	[illegible]	656	[illegible]	[illegible]4
Management Only			[illegible]				[illegible]	[illegible]	[illegible]	44	[illegible]	[illegible]69
Management, Veg. & Mechanical			[illegible]		[illegible]	[illegible]	[illegible]	[illegible],721	20,40[illegible]	61[illegible]	78,500	2,355
Range	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	56[illegible]	[illegible],134	[illegible],847,000	6,946
Management Only			[illegible]		[illegible]	[illegible]	[illegible]	[illegible],91[illegible]	408,500	1,021	1,3[illegible]9,900	3,326
Management, Veg. & Mechanical			[illegible]		[illegible]	[illegible]	[illegible]	4,259	159,[illegible]00	1,11[illegible]	517,10[illegible]	[illegible]
Forest Land-Commercial	4[illegible]		[illegible]				[illegible]	1[illegible]	[illegible]	[illegible]	6,40[illegible]	16
Management Only			[illegible]				[illegible]	19	[illegible],000	[illegible]	6,40[illegible]	16
Management, Veg. & Mechanical								[illegible]		[illegible]		[illegible]
Forest Land - Non-Commercial	[illegible]		[illegible]			4	[illegible],900	34	[illegible]	[illegible]	4,[illegible]	[illegible]
Management Only										[illegible]		
Management, Veg. & Mechanical			[illegible]			4	[illegible]	34	[illegible]	[illegible]	4,[illegible]	[illegible]
Other												
Management Only									[illegible]		[illegible]	[illegible]
Management, Veg. & Mechanical												
TOTAL					[illegible],4	6,[illegible]	4[illegible]	[illegible],914	[illegible],749,[illegible]	66,414	[illegible],[illegible]75,[illegible]	99,146
Management Only					[illegible],4	4[illegible]	[illegible]	4,364	422,40[illegible]	1,13[illegible]	1,380,0[illegible]	3,[illegible]
Management, Veg. & Mechanical				[illegible]	[illegible]	2[illegible],1[illegible]	[illegible]9[illegible]	1[illegible]4,[illegible]	1,3[illegible],80[illegible]	65,[illegible]	2,195,[illegible]	95,[illegible]

1/ Figures rounded [illegible] with [illegible]

2/ Accumulative from 1975 [illegible]

3/ 93,100 acres [illegible] 91,[illegible] [illegible] cultural [illegible] we[illegible] [illegible] [illegible] 19[illegible]

Table V-7 Land Conservation on Federal Land
Planning Area North Dakota Tribs, North Dakota

Land Use or Treatment Practice	1975 TREATMENT DATA: Total Land (Acres) 1/	Adequately Treated (Acres)	Land Needing Treatment (Acres)	Estimated Unit Treatment Cost Per Acre	1985: Treatment Completed w/Ongoing Program (Acres) 2/	Cost of Ongoing Program ($1,000)	Remaining Land Needing Treatment (Acres)	Remaining Land Treatment Costs ($1,000)	Treatment Completed w/Ongoing Program (Acres)	Cost of Ongoing Program ($1,000)	Remaining Land Needing Treatment (Acres)	Remaining Land Treatment Costs ($1,000)
BUREAU OF LAND MANAGEMENT												
Rangeland	[illegible]	[illegible]	44,[illegible]	--	5,000	66	39,000	470	16,[illegible]	[illegible]	[illegible]	[illegible]
Management Only			[illegible]	[illegible].00	3,000	6	25,000	50	8,[illegible]	1[illegible]	20,000	4
Management, Veg. & Mechanical			16,[illegible]	30.00	2,000	60	14,000	420	8,000	24	8,000	[illegible]4
Forest Land				--	[illegible]	0	0	0	0	[illegible]	[illegible]	0
Management Only												
Management, Veg. & Mechanical												
Urban and Build-up		[illegible]	[illegible]	--	[illegible]	[illegible]	0	0	0	0	0	0
Management Only												
Management, Veg. & Mechanical												
Barren Land or Tundra		[illegible]	0	--	0	0	0	0	0	0	0	0
Management Only												
Management, Veg. & Mechanical												
FOREST SERVICE												
Rangeland	969,500	566,800	402,700	--	395,800	2,062	6,900	2,456	397,200	2,560	5,500	1,958
Management Only			0	--	0	0	0	0	0	0	0	0
Management, Veg. & Mechanical		566,800	402,700	11.00 3/	395,800	2,062	6,900	2,456	397,200	2,560	5,500	1,958
Forest Land (Commercial)	0	0	0	--	0	0	0	0	0	0	0	0
Management Only												
Management, Veg. & Mechanical												
Forest Land (Non-Commercial)	64,900	64,900	0	--	0	0	0	0	0	0	0	0
Management Only												
Management, Veg. & Mechanical												
Barren Land or Tundra 4/	0	0	0	--	0	0	0	0	0	0	0	0
Management Only												
Management Veg. & Mechanical												
OTHER FEDERAL LAND	498,840	498,840	0	--	0	0	0	0	0	0	0	0
TOTAL	1,558,840 5/	1,142,140 5/	446,700	XX	400,800	2,128	45,900	2,926	412,200	2,816	33,500	2,238
Management Only			28,000	XX	3,000	6	25,000	50	8,000	16	20,000	40
Management, Veg. & Mechanical			418,700	XX	397,000	2,122	20,900	2,876	405,200	2,800	13,500	2,198

1/ Figures rounded from "Land Use" Work Item No. 11.

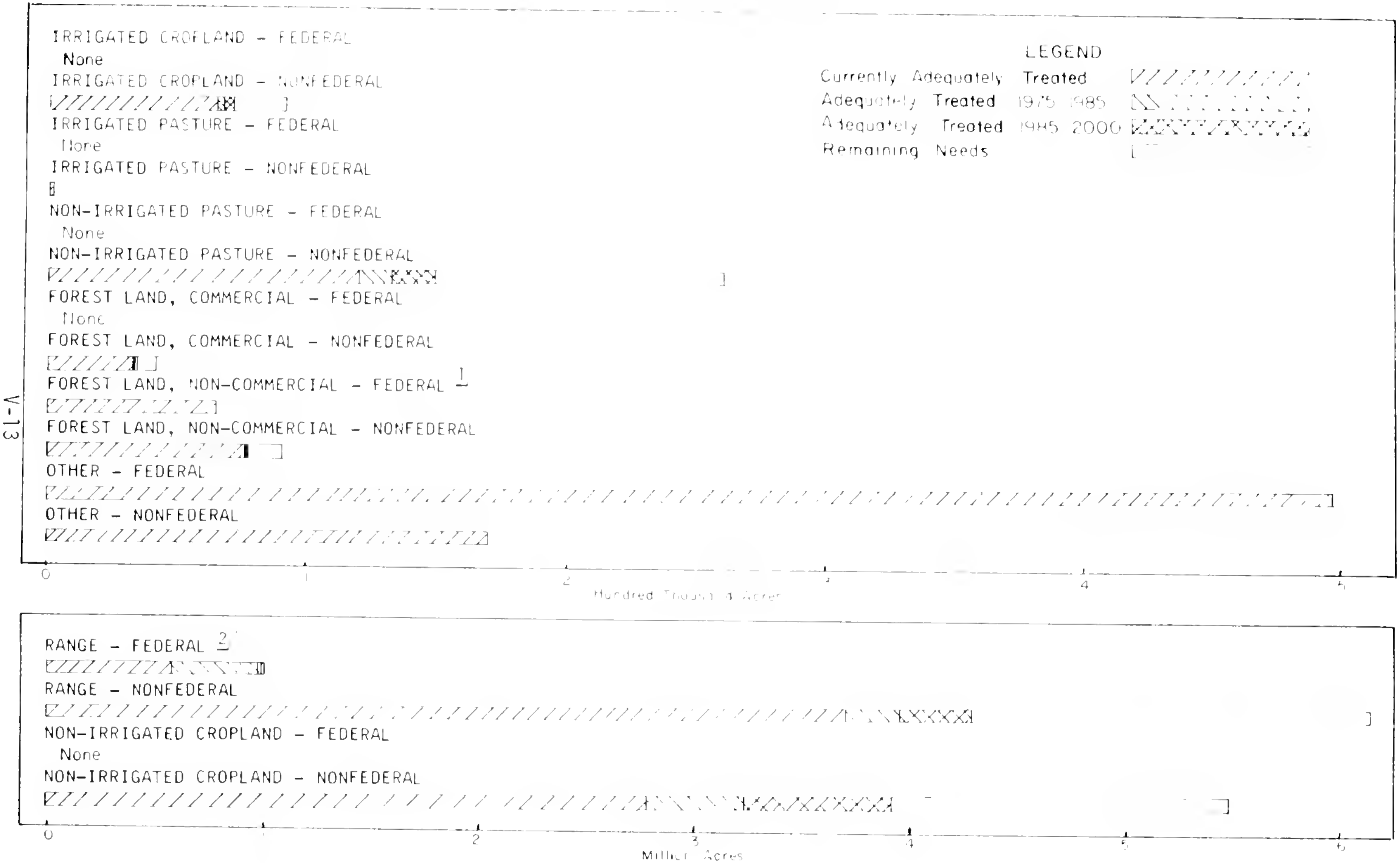
2/ Accumulative from 1975 to year indicated.

3/ Treatment completed by year 1985, and 2000, and costs for ongoing and remaining needs are not simple multiplications of average cost times acres. The costs are reflections of the actual work anticipated to be completed, actual acreages and actual costs. The most expensive programs per acre are generally the remaining needs in 1985 and 2000, and thus a high acre cost is shown.

4/ Included in rangeland.

5/ Water acreage from BLM and other Federal land categories is included in total.

Figure V-1. Land Conservation Status by Planning Area
North Dakota Tribs, North Dakota



1/ Includes all BLM forest land as non-commercial
2/ Barren land and tundra are included in range

centive programs to preserve but not to provide additional habitat areas. Under future without conditions these ongoing programs are assumed to continue at their present level.

Outdoor Recreation

There are approximately 8,038 acres of private recreation areas in the planning area. The largest is the Wallace Carson hunting area, containing 3,000 acres in McKenzie County. Other areas include campgrounds, rodeo grounds, roping areas, gun clubs, and golf courses. Privately owned campgrounds comprise 39 percent of the total camping capacity in the planning area. The rodeo grounds and roping areas are nearly 100 percent privately owned. There are eight private country clubs, with a total of 510 acres. This represents 60 percent of the total number of courses. Of the 48 total private water-based areas 39 are either private lakes or reservoirs. Of these 78 percent are considered underdeveloped, therefore, some potential for water recreation from the private sector is expected. The developed areas emphasize activities such as boating, sailing, picnicking, camping and swimming. Most of these lakes or reservoirs are under 20 acres in size. The remainder of the private areas are non profit operations such as 4-H, Boy Scouts, WMCA's and church camps.

Nonenergy Minerals

The private enterprise sector has in the past met the needed water requirements in developing nonenergy minerals. The majority of this need has been met by underground water supplies, or in the case of sand and gravel processing for highway construction from the temporary use of available surface waters. Because of the relatively insignificant projected need for water for nonenergy mineral production, it is likely that private enterprise will continue to meet this need without additional governmental involvement; therefore, the water requirements as projected in chapter four reflect the future without conditions.

Summary of Future Without Plan Conditions

Future conditions without a plan were estimated to determine the resource capabilities and expected conditions without additional government involvement

in the preceeding section. Figure V-2 summarized in general terms, the course of events without a plan, assuming the continuation of ongoing programs and under existing conditions.

Impacts of Future Without Developments on the Study Areas Water Resources

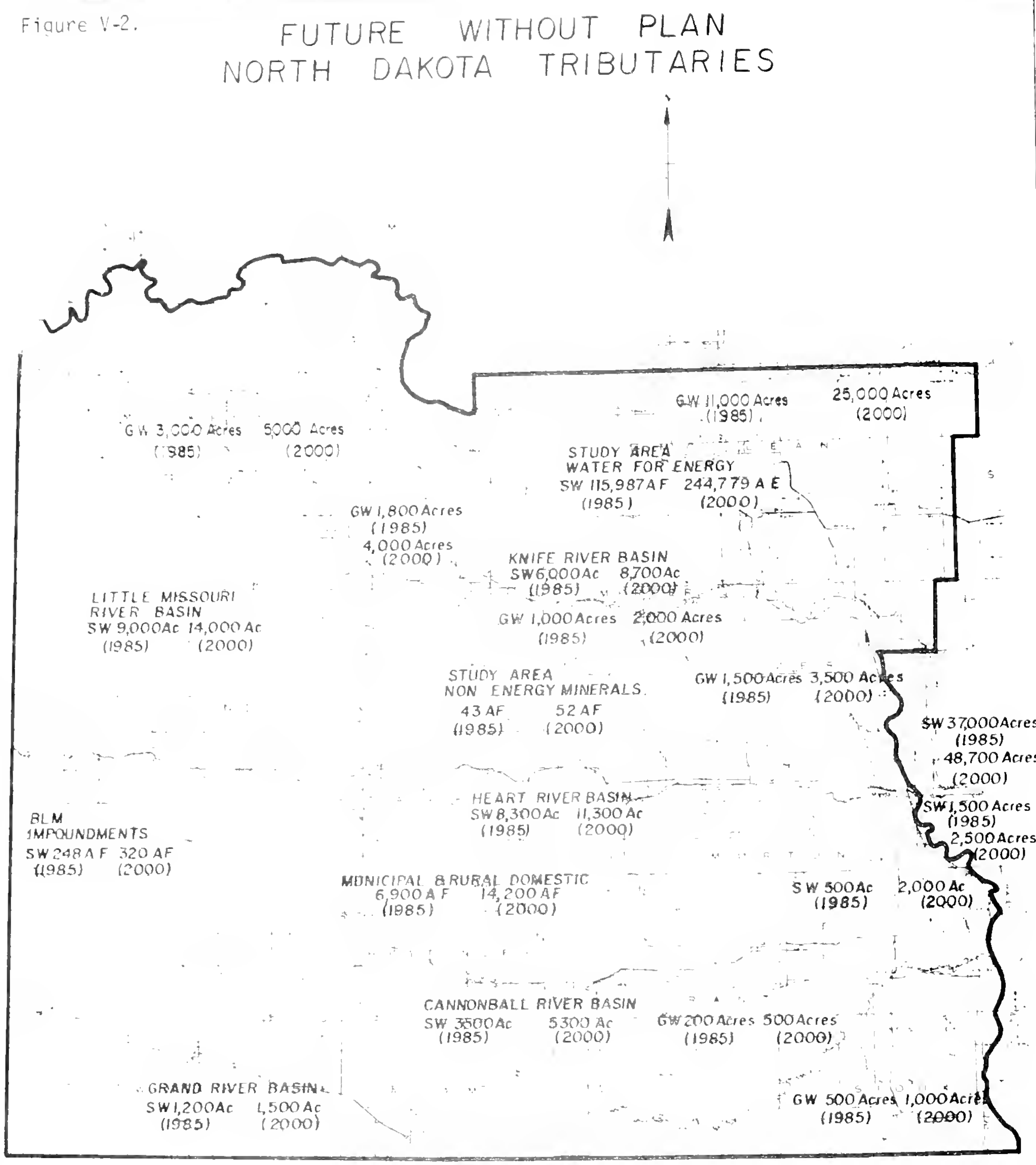
Predicted depletions for the future without plan for the years 1985 and 2000 were based on the potential needs of private irrigation and Bureau of Land Management impoundment needs. Water requirements for energy development were assumed to be provided from the Missouri River. The private irrigation growth from surface water was assumed to be in the form of waterspreading. Water allocations were developed for water spreading, during the high runoff months, at a rate of 0.5 acre-feet/acre. Based on historic flow data, the high runoff months are March, April, May and June.

It was determined that water spreading would deplete the average annual streamflow by 0.5 acre-feet/acre over the four months of high runoff. To determine what the depletion would be for any one month, a percent of depletion for each month was computed based on the average historical flows for the four months of high runoff. Table V-8 presents the average historic percentage of depletion and the monthly depletions for 1985 and 2000.

Summary tables (V-9 through V-16) show the future without plan depletions for 1985 and 2000 by river basin and gaging station. The necessary computations were; 1) update the monthly historic flows at the specified stations to 1975 conditions, 2) update the monthly depletions to 1975 conditions and 3) compute the 1985 and 2000 depletion level by subtracting the accumulative added monthly depletion to the present condition flows at these stations.

Under the future without plan conditons the Knife River at Hazen, the 1975 depletion level average flow of 119,260 AF/year is predicted to decline to 113,990 AF/year by 1985 and to 112,790 AF/year by the year 2000. The Heart River at Mandan 1975 depletion level average flow of 160,710 AF/year is predicted to decline to 141,150 AF/year by 1985 and to 139,740 AF/year by the year 2000. The Little Missouri River near Watford City, 1975 depletion level average flow of 420,950 AF/

Figure V-2.



IRRIGATION ACRES (INCLUDED IS 56,000 ACRES OF EXISTING)
SW - SURFACE WATER SOURCE SHOWN BY DRAINAGE BASIN
GW - GROUNDWATER SOURCE SHOWN BY COUNTY

YELLOWSTONE BASIN AND ADJACENT COAL AREA LEVEL B STUDY
MISSOURI RIVER BASIN COMMISSION

Table V-8. Monthly Distribution and Percent Allocation Per Month

	Knife River At Hazen**	Heart River At Mandan**	Cannonball River At Breien**	Little Missouri River At Watford City**	
Historical Average (1000 AF)	40.73	49.13	48.11	127.06	March
	35.44	52.06	50.13	101.92	April
	10.22	20.57	19.21	49.77	May
	17.33	23.07	25.43	80.66	June
Percent Distribution of Depletion	.39	.34	.34	.35	March
	.34	.36	.35	.28	April
	.10	.14	.13	.14	May
	.17	.16	.18	.23	June
Projected* 1985 Monthly Depletion (1000 AF)	1.17	1.41	.59	1.64	March
	1.02	1.49	.61	1.31	April
	.30	.58	.22	.65	May
	.50	.66	.31	1.07	June
Projected* 2000 Monthly Depletion (1000 AF)	1.70	1.92	.90	2.53	March
	1.48	2.03	.92	2.03	April
	.44	.79	.34	1.01	May
	.73	.90	.47	1.66	June

* Based on .5 acre-feet/acre water spreading useage.

** Projected acreage and year: Knife River, 6,000 acres, 1985: 8,700 acres, 2000: Heart River, 8,300 acres, 1985; 11,300 acres, 2000; Cannonball River, 3,500 acres, 1985; 5,300 acres, 2000; Little Missouri River, 9,000 acres, 1985; 14,000 acres, 2000.

year is predicted to decline to 407,790 AF/year by 1985 and to 405,420 AF/year by the year 2000. The Cannonball River at Breien, 1975 depletion level average flow of 158,330 AF/year is predicted to decline to 143,520 AF/year by 1985 and to 142,730 AF/year by the year 2000.

Projected increased irrigation in the without plan is not the normal commercial type of irrigation. The system to irrigate the land is the water spreading type. Using this system, water is diverted during high flow during the spring runoff season.

If the level of private surface water irrigation development projected to 1985 and 2000 were of the commercial type such as sprinkler or gravity systems, that would require water during the months of July and August, severe shortages in streamflows would occur during those months. For example, the Knife River at Hazen (1975 depletion levels) would have had zero flow during August, 14 out of the 46 years on record (1930-1975). With the higher year 2000 projected level, zero flow during August would have occurred 31 out of the 46 years on record.

1985 DEPLETION LEVEL WITHOUT STA 6-3405

Table V-9. 1985 Future Without Plan Depletion Level, Station 6-3405, Knife River at Hazen

UNITS - 1000AF

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1930	.69	.81	.17	.05	51.22	59.10	9.60	3.68	13.09	0.00	0.00	.64	139.05
1931	1.04	1.05	.36	.36	.2[illegible]	.37	.18	0.00	1.96	.44	1.20	7.53	14.75
1932	1.68	.62	.17	.05	1.07	14.90	5.77	2.71	12.79	0.00	0.00	.45	40.20
1933	1.23	2.15	.44	.16	4.02	70.20	7.90	5.83	.22	0.00	0.00	0.00	92.15
1934	.17	.26	0.00	0.00	.12	0.00	0.00	0.00	.89	0.00	0.00	0.00	1.44
1935	.27	.16	0.00	0.00	0.00	.10	0.00	2.42	9.49	24.89	.45	0.00	37.78
1936	.27	.16	0.00	0.00	0.00	30.10	10.00	.32	0.00	0.00	0.00	0.00	40.85
1937	.17	.26	0.00	0.00	0.07	15.80	19.50	1.72	88.99	25.29	26.05	.39	178.17
1938	1.16	1.48	.24	.21	0.00	26.75	1.71	4.15	9.42	58.17	9.87	1.51	114.66
1939	1.99	1.57	.77	.56	.37	87.61	5.47	2.92	2.78	3.40	.38	.89	109.20
1940	1.27	1.37	1.17	.29	.20	0.00	2.46	4.27	0.00	5.50	0.00	.04	16.67
1941	1.53	.87	.51	.29	0.0[illegible]	11.71	4.30	4.42	49.93	0.00	0.00	2.90	76.47
1942	3.16	1.38	.76	.51	.22	23.30	21.76	4.68	27.90	2.32	1.13	.98	88.15
1943	1.57	1.35	.27	.26	18.37	195.50	44.93	4.54	25.44	8.73	3.54	2.31	306.82
1944	2.46	3.42	2.14	.88	.82	10.07	75.39	6.52	60.24	12.39	.79	1.69	176.81
1945	2.33	3.70	.96	1.02	5.2[illegible]	127.00	8.32	3.18	16.62	1.45	.66	1.10	171.58
1946	1.78	1.77	.71	.84	5.94	35.48	1.06	.44	5.97	7.48	0.00	.71	62.20
1947	2.40	1.64	.90	6.13	10.12	39.69	44.40	2.10	49.39	7.24	3.52	1.48	175.01
1948	2.23	1.96	1.53	1.07	.83	84.06	45.29	10.68	16.20	2.67	.71	.71	167.94
1949	1.65	2.02	1.12	.83	.17	6.23	125.30	5.51	3.87	1.33	1.50	1.12	150.44
1950	2.24	1.96	1.14	.51	.03	22.83	197.40	27.16	5.12	2.60	1.89	2.43	265.31
1951	2.96	2.16	1.78	1.68	.95	40.57	102.90	7.46	6.25	2.67	5.66	4.36	179.52
1952	3.01	2.20	1.89	1.00	1.55	0.00	253.20	6.43	4.22	4.70	2.01	2.02	282.26
1953	2.23	2.32	1.93	1.29	1.44	8.79	2.55	10.47	38.30	2.72	.93	.73	73.70
1954	1.66	1.64	1.49	1.01	22.65	6.98	39.69	2.96	5.75	.06	11.87	6.83	102.59
1955	2.09	1.91	1.83	1.13	1.27	16.37	12.48	1.62	1.60	1.25	0.00	.56	42.12
1956	1.06	.98	.66	.30	.65	55.14	8.05	2.61	5.22	1.77	.84	.76	77.42
1957	1.21	1.42	1.09	.57	2.71	23.39	3.70	1.95	12.05	4.57	0.00	.32	52.98
1958	1.32	1.27	1.43	.92	.55	19.13	11.26	.31	0.00	11.08	0.00	0.00	47.27
1959	.65	1.27	.60	.14	0.00	66.35	8.79	1.09	.64	0.90	0.00	.79	[illegible]
1960	2.06	1.08	1.06	.42	.24	83.40	7.55	2.27	2.41	.28	.56	.38	100.76
1961	.86	.97	.62	.44	1.5[illegible]	7.99	.08	.92	0.00	0.00	0.00	0.00	13.41
1962	.67	.72	.17	0.00	0.00	8.05	2.18	18.35	36.42	18.50	2.71	.96	88.72
1963	1.42	1.39	1.20	.28	.4[illegible]	4.91	3.98	5.85	12.82	4.29	3.43	.84	40.85
1964	1.07	1.40	.69	.25	.3	0.00	2.51	4.24	22.33	11.83	0.00	2.90	47.59
1965	1.19	1.25	.81	.43	.40	0.00	58.96	29.02	17.17	12.33	1.90	1.80	125.26
1966	1.88	1.68	1.25	.37	.12	55.27	2.47	2.47	44.03	16.22	5.78	.80	132.34
1967	1.58	.95	.93	.80	.57	120.60	36.80	43.57	11.48	1.80	.96	1.37	221.36
1968	2.13	2.06	1.80	.42	.4[illegible]	22.56	2.74	2.27	3.35	.13	4.00	1.19	43.18
1969	1.52	1.91	1.18	.38	.6[illegible]	15.74	139.20	4.84	3.68	30.73	5.22	1.45	206.44
1970	2.00	1.89	1.89	.90	1.0[illegible]	1.08	35.03	93.20	20.44	7.89	4.33	1.98	171.71
1971	3.26	3.05	2.00	1.17	8.11	80.42	31.55	6.20	41.77	3.72	.43	2.50	184.18
1972	5.68	.99	1.01	1.44	1.6[illegible]	187.05	13.93	21.75	25.83	4.24	5.63	2.08	271.27
1973	4.11	3.77	1.82	4.00	4.25	51.58	4.83	3.53	3.14	.06	.22	.60	86.94
1974	1.43	1.82	1.43	8.94	12.71	20.79	10.00	7.[illegible]2	3.25	.22	.43	.38	68.91
1975	.93	1.39	1.34	.86	.5[illegible]	1.05	110.53	46.99	15.62	6.41	2.70	1.55	190.49
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVG	1.[illegible]	1.52	.96	.91	3.7[illegible]	37.4[illegible]	32.[illegible]	9.0[illegible]	15.[illegible]	[illegible].63	2.37	1.36	113.99

V-19

Table V-10. 2000 Future Without Plan Depletion Level, Station 6-3405, Knife River at Hazen

UNITS - 1000AF

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1930	.69	.81	.17	.05	51.22	58.58	9.14	3.54	12.86	0.00	0.00	.64	137.70
1931	1.04	1.05	.36	.36	.2	0.00	0.00	0.00	1.73	.44	1.20	7.53	13.97
1932	1.68	.62	.17	.05	1.07	14.38	5.31	2.57	12.56	0.00	0.00	.45	38.85
1933	1.23	2.15	.44	.16	4.02	69.68	7.44	5.69	0.00	0.00	0.00	0.00	90.81
1934	.17	.26	0.00	0.00	.1	0.00	0.00	0.00	.66	0.00	0.00	0.00	1.21
1935	.27	.16	0.00	0.00	0.00	0.00	0.00	2.28	9.26	24.89	.45	0.00	37.31
1936	.27	.16	0.00	0.00	0.01	29.58	9.54	.18	0.00	0.00	0.00	0.00	39.73
1937	.17	.26	0.00	0.00	0.05	15.28	19.04	1.58	88.76	25.29	26.05	.39	176.81
1938	1.16	1.48	.24	.21	0.01	26.23	1.25	4.01	9.19	58.17	9.87	1.51	113.30
1939	1.99	1.57	.77	.56	.37	87.09	5.51	2.78	2.55	3.40	.38	.89	107.85
1940	1.27	1.37	1.17	.29	.20	0.00	2.00	4.13	0.00	5.60	0.00	.04	16.07
1941	1.53	.87	.51	.29	0.06	11.19	3.84	4.28	49.70	0.00	0.00	2.90	75.11
1942	3.16	1.38	.76	.51	.28	22.78	21.30	4.54	27.67	2.32	1.13	.98	85.80
1943	1.57	1.35	.27	.26	18.39	194.98	44.47	4.30	25.21	8.73	3.54	2.31	305.47
1944	2.46	3.42	2.14	.88	.84	9.55	74.93	6.38	60.01	12.39	.79	1.69	175.45
1945	2.33	3.70	.96	1.02	5.24	125.48	7.86	3.04	16.39	1.45	.66	1.10	170.22
1946	1.78	1.77	.71	.84	5.94	34.96	.60	.30	5.74	7.48	0.00	.71	60.85
1947	2.40	1.64	.90	6.13	16.12	39.17	43.94	1.95	49.16	7.24	3.52	1.48	173.65
1948	2.23	1.96	1.53	1.07	.83	83.54	44.83	10.54	15.97	2.67	.71	.71	166.58
1949	1.65	2.02	1.12	.63	.17	5.71	124.84	5.37	3.64	1.33	1.50	1.12	149.09
1950	2.24	1.95	1.14	.51	.03	22.31	196.94	27.02	4.89	2.60	1.89	2.43	263.95
1951	2.96	2.16	1.78	1.68	.95	40.17	102.44	7.32	6.02	2.67	5.66	4.36	178.16
1952	3.01	2.20	1.89	1.00	1.59	0.00	252.74	6.29	3.99	4.70	2.01	2.02	281.44
1953	2.23	2.32	1.93	1.29	1.44	8.27	2.09	10.33	38.07	2.72	.93	.73	72.34
1954	1.66	1.64	1.49	1.01	22.65	6.46	39.23	2.82	5.52	.06	11.87	6.83	101.23
1955	2.09	1.91	1.83	1.13	1.29	15.85	12.02	1.48	1.37	1.25	0.00	.56	40.76
1956	1.06	.98	.66	.30	.05	54.62	7.59	2.47	4.99	1.77	.84	.76	76.07
1957	1.21	1.42	1.09	.57	2.71	22.87	3.24	1.81	11.82	4.57	0.00	.32	51.63
1958	1.32	1.27	1.43	.92	.55	18.51	10.80	.17	0.00	11.08	0.00	0.00	46.15
1959	.85	1.27	.60	.14	0.05	65.83	8.33	.95	.41	0.00	0.00	.72	79.16
1960	2.06	1.08	1.06	.42	.24	62.94	7.03	1.13	2.18	.28	.56	.38	39.41
1961	.85	.97	.62	.44	1.54	7.47	0.00	.78	0.00	0.00	0.00	0.00	12.67
1962	.67	.72	.17	0.00	0.00	7.53	1.72	18.21	36.19	18.50	2.71	.96	67.37
1963	1.42	1.39	1.20	.28	.44	4.39	3.52	5.71	12.59	4.29	3.43	.84	39.49
1964	1.07	1.40	.69	.25	.31	0.00	2.05	4.10	22.10	11.63	0.00	2.90	46.76
1965	1.19	1.25	.81	.43	.41	0.00	58.50	28.88	16.94	12.33	1.90	1.80	124.43
1966	1.88	1.68	1.25	.37	.14	54.75	2.01	2.33	43.80	16.22	5.78	.80	130.99
1967	1.56	.95	.93	.80	.55	120.08	36.34	43.43	11.25	1.80	.96	1.37	220.01
1968	2.13	2.06	1.80	.42	.44	22.04	2.33	2.13	3.12	.13	4.00	1.19	41.83
1969	1.52	1.91	1.18	.38	.61	15.22	138.74	4.70	3.45	30.73	5.22	1.45	205.09
1970	2.00	1.89	1.89	.90	1.01	.56	34.57	93.06	20.21	7.89	4.33	1.98	170.35
1971	3.26	3.05	2.00	1.17	8.11	79.90	31.09	6.06	41.54	3.72	.43	2.50	182.82
1972	5.68	.99	1.01	1.44	1.64	186.52	13.48	21.61	25.60	4.24	5.63	2.08	269.92
1973	4.11	3.77	1.82	4.00	9.25	51.05	4.38	3.39	2.91	.06	.22	.60	85.58
1974	1.43	1.82	1.43	6.94	12.71	20.25	9.54	7.38	3.02	.22	.43	.38	67.56
1975	.93	1.39	1.34	.88	.51	1.12	110.07	45.85	15.39	6.41	2.70	1.55	149.13
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVG	1.69	1.52	.96	.91	3.71	[illegible]	32.27	8.84	15.50	5.63	2.37	1.36	112.79

1985 DEPLETION LEVEL WITHOUT STA 6-3490

Table V-11. 1985 Future Without Plan Depletion Level, Station 6-3490, Heart River at Mandan

UNITS - 1000AF

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1929	3.25	2.28	.92	.01	0.00	28.56	17.44	6.63	32.51	0.00	2.41	3.03	97.04
1930	3.36	2.94	1.50	0.00	17.82	66.60	25.14	7.16	15.01	0.00	3.60	3.30	146.42
1931	.92	1.15	.76	.91	6.31	3.85	4.82	3.67	6.61	0.00	2.87	2.63	34.51
1932	2.60	1.21	.98	.01	5.7	11.76	7.30	2.06	11.61	0.00	2.21	2.21	48.61
1933	2.19	3.00	1.40	.00	.30	46.96	14.04	10.21	9.51	0.00	2.49	2.32	92.44
1934	2.89	1.90	1.50	.20	.23	9.66	8.94	2.41	7.61	0.00	2.59	2.52	40.44
1935	1.39	1.20	.50	0.00	0.0	6.66	.84	1.91	11.61	0.00	1.69	2.32	28.13
1936	1.29	.90	.40	.00	0.05	8.86	4.74	1.51	1.41	0.00	2.39	2.72	24.24
1937	.79	.70	.20	0.00	0.00	8.06	4.74	1.21	47.51	0.00	2.39	2.42	68.03
1938	.97	1.82	1.22	.30	.05	16.57	2.88	2.38	13.94	0.00	3.94	2.54	46.61
1939	3.02	2.75	1.35	.53	.3	50.36	18.74	7.41	13.10	0.00	2.23	2.72	102.51
1940	2.12	2.25	1.30	.37	.2	4.51	11.75	7.88	2.53	0.00	2.30	2.26	37.57
1941	1.62	1.54	1.24	.23	.0	25.56	9.67	9.48	72.71	0.00	2.44	3.11	126.91
1942	4.12	2.95	.93	0.09	0.0	14.09	20.20	16.72	26.80	0.00	2.88	2.57	90.37
1943	1.74	1.71	.27	0.00	19.7	143.06	[illegible]	49.84	57.73	0.00	4.84	3.57	377.79
1944	1.98	3.78	1.43	.21	.34	8.86	77.34	42.95	65.85	0.00	3.25	3.54	209.59
1945	2.26	4.39	1.32	.47	9.21	97.06	75.71	32.70	13.70	0.00	3.47	2.80	243.10
1946	1.58	1.40	.86	0.00	.14	21.18	3.03	1.52	4.06	0.00	2.47	2.66	38.90
1947	1.97	1.76	.82	0.00	14.7	37.94	51.33	46.86	51.96	0.00	5.29	2.81	215.54
1948	1.78	1.74	1.28	.24	.07	101.46	60.15	50.85	13.53	0.00	5.76	3.00	239.81
1949	1.12	1.82	.89	0.00	.0	52.65	121.64	28.65	17.64	0.00	2.62	2.89	229.93
1950	2.81	1.71	.79	.10	.1	3.79	382.94	85.33	19.45	0.00	3.48	3.14	503.64
1951	3.34	2.15	1.35	.93	.7	81.37	120.84	10.21	6.94	0.00	8.86	7.10	243.90
1952	5.29	4.38	1.41	.15	.2	0.00	332.74	14.03	9.95	0.00	7.00	8.58	383.78
1953	4.73	5.36	.73	.38	.6	4.31	3.52	9.28	35.16	0.00	5.32	5.25	74.65
1954	6.66	2.17	4.73	3.48	13.47	9.34	61.14	13.36	5.70	0.00	4.08	4.05	128.14
1955	2.88	2.44	1.62	.28	.4	3.90	3.63	2.53	5.42	0.00	3.72	1.56	28.39
1956	3.06	3.26	3.06	2.12	1.3	47.24	17.44	8.76	5.84	0.00	3.21	2.39	97.72
1957	3.63	5.48	1.78	.51	.07	3.29	3.88	3.41	7.85	0.00	1.61	2.03	33.34
1958	3.27	3.72	1.70	.71	.32	14.20	16.88	3.59	6.68	0.00	2.70	2.88	[illegible]
1959	3.17	2.21	.51	0.00	0.00	62.05	25.10	3.04	2.83	0.00	2.15	2.42	103.45
1960	3.50	1.76	1.53	.81	.37	36.39	16.73	3.71	14.19	0.00	2.22	3.06	84.75
1961	2.15	1.75	1.28	.59	.34	.86	.34	.52	.50	0.00	.76	1.68	10.76
1962	.89	.82	.32	0.00	0.05	6.25	2.24	8.89	12.15	0.00	1.77	2.35	35.68
1963	1.02	1.73	1.19	.07	0.03	2.44	2.20	2.44	9.30	0.00	8.74	3.63	32.77
1964	3.16	2.49	1.18	.28	.42	0.00	2.91	3.02	24.18	0.00	4.16	2.96	44.77
1965	3.34	1.76	.45	0.00	0.00	0.00	40.44	31.31	33.84	0.00	5.35	6.64	123.14
1966	4.92	1.92	2.13	.41	0.0	99.16	14.75	5.03	60.02	0.00	7.78	4.56	200.69
1967	3.62	2.41	1.63	1.23	1.0	115.06	44.91	108.11	10.32	0.00	6.01	5.01	305.36
1968	3.00	2.17	1.56	.04	.3	12.09	2.97	1.46	7.36	0.00	6.35	2.16	39.56
1969	1.39	.98	.60	.16	.0	2.32	255.44	11.04	8.07	0.00	6.62	6.27	293.05
1970	2.81	2.40	1.84	.97	.9	0.00	32.97	221.31	33.38	0.00	10.00	6.38	313.03
1971	3.41	2.11	1.37	.48	1.5	102.06	70.55	18.43	35.48	0.00	5.60	6.01	247.04
1972	3.65	1.71	1.90	1.44	.65	169.93	50.45	69.37	55.18	0.00	10.69	7.48	372.50
1973	2.50	2.97	2.24	3.21	15.7	85.94	9.39	8.02	5.46	0.00	5.14	3.55	144.20
1974	1.80	1.95	1.96	2.77	4.4	7.17	4.40	3.03	3.22	0.00	3.25	2.47	35.44
1975	1.97	1.85	1.53	[illegible]	.1	[illegible]	131.40	123.25	26.45	0.00	7.91	3.63	299.24
1976	0.00	0.00	0.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	0.00	0.00	0.00
AVG	2.50	2.21	[illegible]	.52	2.4	34.13	[illegible]	25.07	19.62	0.00	4.14	3.44	141.15

Table V-12. 2000 Future Without Plan Depletion Level, Station 6-3490, Heart River at Mandan

UNITS - 1000AF

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
3.25	2.28	.92	.01	0.0[illegible]	28.05	16.90	6.42	32.27	0.00	2.41	3.03	95.54
3.36	2.94	1.50	0.00	17.87	66.09	24.60	6.95	14.77	0.00	3.60	3.30	144.92
.92	1.15	.76	.91	6.3[illegible]	3.34	4.26	3.46	6.37	0.00	2.87	2.43	33.01
2.60	1.21	.98	.01	5.79	11.25	6.76	2.75	11.37	0.00	2.21	2.21	47.11
2.19	3.00	1.40	.00	.3[illegible]	46.45	13.50	10.00	9.27	0.00	2.49	2.32	90.94
2.89	1.90	1.50	.20	.2[illegible]	9.15	8.40	2.20	7.37	0.00	2.59	2.52	38.94
1.39	1.20	.50	0.00	0.0[illegible]	6.15	.30	1.70	11.37	0.00	1.69	2.32	26.63
1.29	.90	.40	.00	0.00	8.35	4.20	1.30	1.17	0.00	2.39	2.72	22.74
.79	.70	.20	0.00	0.00	7.55	4.20	1.00	47.27	0.00	2.39	2.42	66.53
.97	1.82	1.22	.30	.0[illegible]	16.06	2.34	2.17	13.70	0.00	3.94	2.54	45.11
3.02	2.75	1.35	.53	.3[illegible]	49.85	16.20	7.20	12.86	0.00	2.23	2.72	101.01
2.12	2.25	1.30	.37	.2[illegible]	4.00	11.21	7.67	2.39	0.00	2.30	2.26	36.07
1.62	1.64	1.24	.23	.0[illegible]	25.05	8.33	9.27	72.47	0.00	2.44	3.11	125.41
4.12	2.05	.53	0.00	0.0[illegible]	13.58	19.66	16.51	26.56	0.00	2.88	2.57	88.87
1.74	1.71	.2[illegible]	[illegible]	19.[illegible]	142.55	94.51	49.63	57.49	0.00	4.84	3.57	376.29
1.98	3.78	1.43	.21	.38	8.35	76.80	42.74	65.61	0.00	3.25	3.54	208.09
2.26	4.39	1.32	.47	9.21	96.55	75.17	32.49	13.46	0.00	3.47	2.80	241.60
1.58	1.40	.86	0.00	.14	20.57	2.49	1.31	3.82	0.00	2.47	2.66	37.40
1.97	1.76	.82	0.00	14.79	37.43	50.79	46.65	51.72	0.00	5.29	2.81	214.04
1.78	1.74	1.26	.24	.00	100.95	59.61	50.64	13.29	0.00	5.76	3.00	238.31
1.12	1.82	.89	0.00	.00	52.14	121.10	28.44	17.40	0.00	2.62	2.89	228.43
2.81	1.71	.79	.10	.15	3.28	382.40	85.12	19.21	0.00	3.48	3.14	502.14
3.34	2.15	1.35	.93	.74	80.86	120.30	10.00	6.70	0.00	8.86	7.10	242.40
5.29	4.38	1.41	.15	.24	0.00	332.20	13.82	9.71	0.00	7.00	8.58	382.79
4.73	5.36	.73	.38	.61	3.80	2.98	9.07	34.92	0.00	5.32	5.25	73.15
6.88	2.17	4.73	3.48	13.41	8.83	60.60	13.15	5.46	0.00	4.08	4.05	126.64
2.85	2.44	1.62	.28	.40	3.39	3.09	2.32	5.18	0.00	3.72	1.56	26.89
3.06	3.26	3.06	2.12	1.32	46.73	16.90	8.55	5.60	0.00	3.21	2.39	96.22
3.63	5.48	1.78	.51	.07	2.78	3.12	3.20	7.61	0.00	1.61	2.03	31.84
3.27	3.72	1.70	.71	.32	13.69	16.32	3.38	6.44	0.00	2.70	2.88	55.15
3.17	2.21	.51	0.00	0.00	61.54	24.56	2.83	2.59	0.00	2.15	2.42	101.99
3.50	1.76	1.53	.81	.33	36.38	16.19	3.50	13.95	0.00	2.22	3.06	83.25
2.15	1.75	1.28	.59	.33	.35	0.00	.31	.26	0.00	.76	1.68	9.47
.89	.82	.32	0.00	0.0[illegible]	5.74	1.[illegible]0	6.66	11.[illegible]1	0.00	1.77	2.35	34.18
1.02	1.73	1.19	.07	0.00	1.93	1.66	2.23	9.06	0.00	6.74	3.63	31.27
3.16	2.49	1.18	.28	.42	0.00	2.37	2.81	23.94	0.00	4.16	2.96	43.78
3.34	1.76	.45	0.00	0.00	0.00	39.90	31.10	33.60	0.00	5.35	6.64	122.15
4.92	1.92	2.13	.41	0.00	98.65	14.21	4.82	59.78	0.00	7.78	4.56	199.19
3.62	2.41	1.63	1.23	1.0[illegible]	118.55	46.37	107.90	10.08	0.00	6.01	5.01	303.86
3.00	2.17	1.56	.04	.3[illegible]	11.58	2.43	1.25	7.12	0.00	6.35	2.16	38.06
1.39	.98	.66	.16	.09	1.81	254.90	10.83	7.63	0.00	6.62	6.27	291.55
2.81	2.40	1.84	.97	.9[illegible]	0.00	32.43	221.10	33.14	0.00	10.00	6.38	312.04
3.41	2.11	1.37	.48	1.5[illegible]	101.55	70.01	16.22	35.24	0.00	5.60	6.01	245.54
3.65	1.71	1.90	1.44	.69	169.42	49.91	69.16	54.94	0.00	10.69	7.48	371.00
2.50	2.97	2.24	3.21	15.77	85.43	8.85	7.81	5.22	0.00	5.14	3.55	142.70
1.80	1.95	1.98	2.77	4.47	6.66	3.86	2.82	2.98	0.00	3.25	2.47	34.94
1.97	1.85	1.53	.53	.1	0.00	131.36	123.04	26.21	0.00	7.91	3.63	298.21
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.60	2.21	1.26	.52	2.48	33.68	47.12	22.87	19.39	0.00	4.14	3.44	139.74

1985 DEPLETION LEVEL WITHOUT STA 6-3370

Table V-13. 1985 Future Without Plan Depletion Level, ~~Station~~ 6-3370 Little Missouri River Near Watford City

UNITS - 1000AF

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1929	4.88	3.07	.83	.31	.16	426.26	250.46	218.53	353.74	15.34	5.47	3.77	1282.82
1930	14.98	3.37	1.53	.91	75.56	88.86	6.56	4.43	92.34	9.14	10.07	37.27	345.02
1931	2.58	1.67	1.63	1.61	12.46	4.16	5.06	0.00	11.24	18.24	35.97	15.47	110.09
1932	7.28	4.27	1.73	.91	8.06	68.26	136.86	49.73	99.24	46.24	7.07	3.97	433.62
1933	9.48	9.87	1.13	.41	4.24	186.16	52.56	195.13	17.34	7.64	0.00	0.00	483.98
1934	0.00	.67	.23	.41	4.65	0.00	1.66	0.00	17.04	4.44	0.00	0.00	29.12
1935	0.00	.16	.19	.21	.07	1.50	0.00	6.00	36.34	105.74	4.28	0.00	154.48
1936	.08	.20	.29	.22	.06	137.86	52.71	.01	0.00	0.00	0.00	0.00	191.42
1937	0.00	.16	.13	.21	.0	33.66	44.37	2.04	139.54	66.78	83.28	11.80	382.07
1938	5.06	.55	.18	.21	1.95	174.35	11.07	13.00	59.19	72.18	7.93	13.44	359.12
1939	3.39	.71	.70	.56	.06	170.56	18.21	.45	38.00	45.98	4.90	.0	303.62
1940	.22	.29	.37	.25	.07	19.83	41.38	20.35	18.25	17.64	31.38	18.34	168.36
1941	14.45	1.51	.07	.23	.64	26.82	34.67	7.78	180.74	14.41	21.33	68.20	370.83
1942	27.58	3.89	1.68	.23	.0	110.36	47.97	66.83	92.24	6.01	5.42	7.75	370.52
1943	2.01	2.19	.60	.64	167.97	195.56	65.77	6.89	59.57	48.03	22.60	6.54	578.36
1944	1.45	3.27	.26	.35	.0	0.00	490.26	39.75	327.44	51.27	12.51	5.88	932.53
1945	4.18	8.74	.35	.21	9.2	301.66	30.66	4.46	25.82	3.32	2.86	5.02	396.48
1946	5.43	.78	.15	.36	15.7	24.19	10.4	11.01	89.80	25.99	.94	7.55	192.34
1947	50.32	24.43	8.60	4.39	77.8	363.66	226.56	12.53	150.64	71.45	35.68	1.60	1028.17
1948	2.41	1.49	1.00	.24	14.87	185.66	62.05	21.91	52.74	61.42	20.57	.64	424.40
1949	1.10	3.80	.76	.24	.22	346.66	217.46	12.74	0.00	.04	0.00	0.00	583.05
1950	5.36	2.45	.57	.11	.15	72.50	449.96	122.73	14.48	4.61	13.54	7.57	694.04
1951	4.54	1.39	.05	.11	15.84	113.46	31.33	2.93	2.23	7.40	8.70	29.51	216.54
1952	7.76	2.40	.91	.35	.47	46.31	718.76	15.88	3.59	15.61	3.77	1.53	817.34
1953	1.00	1.11	.26	.02	.4	27.63	7.75	58.80	107.94	9.32	16.00	11.62	241.87
1954	5.90	3.02	.85	.05	28.6	4.74	83.24	.27	36.17	5.60	31.24	30.32	230.00
1955	1.71	1.36	.47	.16	.0	43.90	82.11	41.27	65.78	22.48	2.21	0.00	261.76
1956	.33	.35	0.00	.01	.06	41.66	10.96	.45	1.14	28.32	26.37	3.49	103.17
1957	.88	.78	.41	.10	5.7	28.39	18.21	.73	62.59	22.97	6.16	20.10	168.03
1958	3.88	2.99	1.64	.05	.4	55.74	11.19	1.93	38.64	49.02	0.00	0.[illegible]	145.[illegible]
1959	.51	.64	.17	0.00	.0	239.76	34.46	2.42	4.75	4.71	0.00	9.50	296.98
1960	4.87	1.48	1.10	.16	.3	218.46	22.70	2.01	52.11	4.16	5.53	.95	313.87
1961	.33	.58	.06	.01	.07	10.87	2.13	4.67	0.00	3.45	6.51	10.52	39.19
1962	2.69	1.06	.21	.01	.74	45.10	12.53	102.93	154.04	71.80	15.88	2.74	409.71
1963	7.11	2.68	.85	.07	25.84	115.16	60.84	33.21	108.34	19.20	9.92	14.11	397.32
1964	2.53	1.48	.41	.01	.06	0.00	9.62	11.82	75.30	88.03	16.74	11.69	217.69
1965	2.00	1.23	.30	.13	.3	1.48	233.36	95.44	84.65	75.80	8.22	13.06	516.01
1966	3.15	2.16	1.09	.25	.07	121.66	10.61	4.45	8.66	35.87	8.14	.37	196.48
1967	1.47	.74	.20	.11	3.7	155.86	60.27	208.53	140.14	17.34	1.15	12.98	602.57
1968	7.17	2.41	.55	.21	9.31	86.90	6.36	1.40	16.37	9.13	20.99	6.86	167.66
1969	2.16	2.00	.65	.13	.06	229.66	177.96	83.44	37.87	72.34	13.40	.50	616.17
1970	1.37	1.40	.67	.24	.2	7.17	76.26	112.73	81.36	13.58	10.75	3.71	309.48
1971	2.23	3.41	1.10	.19	33.09	427.06	281.76	42.43	304.54	41.58	2.87	33.13	1173.38
1972	145.55	23.36	4.07	3.68	2.74	626.06	53.47	139.06	70.10	30.49	34.89	6.29	1139.76
1973	5.86	3.98	.96	7.43	37.8	110.3	29.54	22.10	62.47	15.15	2.88	21.07	320.64
1974	7.08	4.09	1.89	5.40	7.3	23.8	39.0	66.76	44.16	10.20	7.18	1.05	217.97
1975	.86	3.04	.30	.06	.14	[illegible]	[illegible]	[illegible]	61.50	42.75	5.81	2.40	640.62
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVG	8.02	3.06	.86	.67	11.[illegible]	119.4[illegible]	[illegible]	44.49	72.92	29.44	12.31	9.63	407.79

2000 DEPLETION LEVEL WITHOUT STA 6-3370

Table V-14. 2000 Future Without Plan Depletion Level, Station 6-3370 Little Missouri River near Watford Cit

UNITS - 1000AF

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1929	4.88	3.07	.83	.31	.17	425.36	249.74	218.17	353.15	15.34	5.47	3.77	1280.25
1930	14.98	3.37	1.53	.91	75.56	87.96	5.84	4.07	91.75	9.14	10.07	37.27	342.45
1931	2.58	1.67	1.63	1.61	12.46	3.26	4.34	0.00	10.65	18.24	35.97	15.47	107.88
1932	7.28	4.27	1.73	.91	8.06	67.36	136.14	49.37	98.65	46.24	7.07	3.97	431.05
1933	9.48	9.87	1.13	.41	4.25	185.26	51.84	194.77	16.75	7.64	0.00	0.00	481.41
1934	0.00	.67	.23	.41	4.66	0.00	.44	0.00	16.45	4.44	0.00	0.00	27.81
1935	0.00	.16	.19	.21	.06	.60	0.00	5.64	35.75	105.74	4.28	0.00	152.64
1936	.08	.20	.29	.22	.06	136.96	51.99	0.00	0.00	0.00	0.00	0.00	189.80
1937	0.00	.18	.13	.21	.06	32.78	43.65	1.68	138.95	66.78	83.28	11.80	379.50
1938	5.06	.55	.18	.21	1.99	173.46	10.35	12.64	58.60	72.18	7.93	13.44	356.56
1939	3.39	.71	.70	.56	.06	189.66	17.49	.10	37.41	45.98	4.90	.10	301.06
1940	.22	.29	.37	.25	.06	18.73	40.66	19.99	17.66	17.64	31.38	18.34	165.80
1941	14.45	1.51	.07	.23	.06	25.92	33.95	7.42	180.15	14.41	21.33	68.20	368.27
1942	27.58	3.89	1.68	.23	.06	109.96	47.25	66.47	91.65	6.01	5.42	7.75	367.95
1943	2.01	2.19	.60	.64	167.96	194.66	65.05	6.53	58.98	48.03	22.60	6.54	575.80
1944	1.45	3.27	.26	.35	.04	0.00	489.54	39.39	326.85	51.27	12.51	5.88	930.86
1945	4.18	8.74	.35	.21	9.20	300.76	29.44	4.10	25.23	3.32	2.86	5.02	393.91
1946	5.43	.78	.15	.36	15.7	23.24	9.72	10.65	89.21	25.99	.94	7.55	189.78
1947	50.32	24.43	8.60	4.39	77.81	362.96	226.14	12.17	150.05	71.45	35.68	1.60	1025.60
1948	2.41	1.49	1.00	.24	14.87	184.16	61.33	21.55	52.15	61.42	20.57	.64	421.84
1949	1.10	3.80	.76	.24	.22	345.76	216.74	12.43	0.00	.04	0.00	0.00	581.08
1950	5.36	2.45	.57	.11	.16	71.50	449.24	122.37	13.89	4.61	13.54	7.57	691.48
1951	4.54	1.39	.05	.11	15.86	112.56	29.61	2.57	1.64	7.40	8.70	29.51	213.97
1952	7.76	2.40	.91	.36	.47	45.41	718.04	15.52	3.00	15.61	3.77	1.53	814.78
1953	1.00	1.11	.25	.02	.42	26.73	7.03	58.44	107.35	9.32	16.00	11.62	239.31
1954	5.90	3.02	.85	.05	28.80	3.84	82.52	0.00	35.58	5.60	31.24	30.32	227.52
1955	1.71	1.36	.47	.16	.06	43.06	81.59	40.91	65.19	22.48	2.21	0.00	259.20
1956	.33	.35	0.00	.01	.0	30.78	10.24	.09	.55	28.32	26.37	3.49	100.60
1957	.88	.78	.41	.10	6.76	27.49	17.49	.37	62.00	22.97	6.16	20.10	165.47
1958	3.88	2.99	1.64	.05	.42	34.34	10.47	1.57	38.05	49.02	0.00	0.00	[illegible]
1959	.51	.64	.17	0.00	.0	238.86	33.74	2.06	4.16	4.71	0.00	9.50	294.42
1960	4.87	1.48	1.10	.16	.36	217.56	21.38	1.65	51.52	4.16	5.53	.95	311.30
1961	.33	.58	.06	.01	.07	9.97	1.41	4.31	0.00	3.45	6.51	10.52	37.22
1962	2.69	1.06	.21	.01	.74	44.20	11.81	102.57	153.45	71.80	15.88	2.74	407.15
1963	7.11	2.68	.85	.07	25.84	114.26	60.12	32.85	107.75	19.20	9.92	14.11	394.75
1964	2.53	1.48	.41	.01	.06	0.00	8.90	11.46	74.71	88.03	16.74	11.69	216.03
1965	2.00	1.23	.30	.13	.34	.58	232.64	95.08	84.06	75.80	8.22	13.06	513.45
1966	3.15	2.16	1.09	.26	.07	120.75	9.89	4.09	8.07	35.87	8.14	.37	193.91
1967	1.47	.74	.20	.11	3.76	154.46	59.55	208.17	139.55	17.34	1.15	12.98	600.01
1968	7.17	2.41	.55	.21	9.31	86.00	5.64	1.04	15.78	9.13	20.99	6.86	165.09
1969	2.16	2.00	.65	.13	.06	224.76	177.24	83.08	37.28	72.34	13.40	.50	613.61
1970	1.37	1.40	.67	.24	.25	6.27	75.54	112.37	80.77	13.58	10.75	3.71	306.92
1971	2.23	3.41	1.10	.19	33.04	426.16	281.04	42.07	303.95	41.58	2.87	33.13	1170.82
1972	145.55	23.30	4.07	3.68	2.74	625.16	52.75	138.70	69.51	30.49	34.89	6.29	1137.19
1973	5.66	3.98	.96	7.43	37.81	109.44	28.02	21.74	61.87	16.15	2.88	21.07	318.08
1974	7.08	4.09	1.89	5.40	7.3	22.35	38.29	66.40	43.57	10.20	7.18	1.05	215.41
1975	.86	3.04	.35	.06	.1	28.71	225.22	263.20	60.91	42.75	5.81	2.40	638.06
1976	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVG.	8.02	3.06	.88	.67	11.5	118.57	94.33	44.16	72.38	29.44	12.31	9.63	405.42

1985 DEPLETION LEVEL WITHOUT STA 6-3540

Table V-15. 1985 Future Without Plan Depletion Level, Station 6-3540, Cannonball River at Breien

UNITS - 1000AF

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1929	.65	.82	.51	.41	.26	130.64	20.99	2.79	28.15	0.00	0.00	.10	185.30
1930	1.25	.62	.31	.31	22.76	45.04	11.99	5.79	1.85	0.00	0.00	.10	90.00
1931	.75	.42	.31	.61	2.46	.24	1.39	0.00	1.45	0.00	0.00	.20	8.01
1932	.05	.32	.01	.11	11.76	31.94	6.79	3.39	47.35	0.00	0.00	0.00	101.70
1933	.35	.42	.21	.21	1.26	45.84	8.59	5.49	0.00	0.00	0.00	0.00	62.35
1934	0.00	.12	.11	.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.23
1935	.55	.12	.01	.01	0.00	3.74	0.00	3.59	6.25	0.00	1.11	0.00	15.36
1936	.05	.12	.01	.01	.36	32.34	4.59	0.00	0.00	0.00	0.00	0.00	37.96
1937	0.00	.12	.01	.01	0.00	16.74	16.29	0.00	138.95	0.00	.71	4.90	177.71
1938	.85	.62	.41	.41	.36	20.44	1.99	.79	29.35	0.00	1.01	3.10	59.31
1939	.55	.72	.71	.21	0.00	41.24	6.14	0.00	10.55	0.00	0.00	.20	60.35
1940	.05	.22	.41	.01	0.00	6.14	14.99	16.39	0.00	0.00	[illegible].31	.30	42.70
1941	.55	.42	.11	.01	0.00	51.84	7.09	1.19	83.05	0.00	0.00	2.40	146.64
1942	2.05	1.02	.51	.11	.16	4.44	15.29	21.69	9.45	0.00	.31	1.10	56.11
1943	.65	.72	.21	.11	17.46	275.44	65.89	6.49	46.75	0.00	1.81	1.40	417.91
1944	.95	2.22	.91	.61	.56	.54	196.09	7.59	82.45	0.00	1.61	1.60	295.21
1945	1.55	4.32	1.31	.81	13.06	82.64	12.99	3.89	16.35	0.00	1.21	1.20	139.31
1946	.45	.92	.81	.21	.3	13.64	3.09	.09	2.85	0.00	0.00	.90	23.30
1947	3.55	1.42	.51	.61	24.96	52.54	55.57	4.09	54.55	0.00	.21	.30	199.31
1948	2.25	1.92	1.21	1.11	2.26	141.94	15.49	6.19	1.85	0.00	3.31	.30	177.81
1949	.35	1.52	.61	.21	0.00	106.64	128.47	17.59	6.35	0.00	2.31	.60	264.65
1950	1.25	.92	.31	.01	0.00	2.74	597.19	69.09	16.15	0.00	10.61	3.50	701.74
1951	3.25	2.52	1.81	1.61	4.06	106.04	28.89	5.39	20.55	0.00	10.91	9.10	194.11
1952	4.15	2.92	1.51	.61	1.06	4.84	427.79	11.89	8.35	0.00	4.11	4.20	471.41
1953	.95	1.22	1.01	.81	1.16	14.44	6.49	47.59	87.15	0.00	4.41	1.10	166.31
1954	1.25	1.82	1.51	.81	9.56	3.74	29.09	2.79	4.28	0.00	2.61	7.80	60.01
1955	.95	1.02	.61	.31	.06	8.64	4.29	2.19	4.35	0.00	3.01	2.30	27.91
1956	.45	.22	.01	.01	0.00	67.64	11.99	3.49	1.25	0.00	3.61	2.30	110.95
1957	.25	2.22	.91	.51	.06	0.00	2.39	7.29	43.65	0.00	2.61	1.00	60.87
1958	1.05	1.82	1.31	.41	.26	15.94	16.19	.79	24.35	0.00	0.00	0.00	62.10
1959	0.00	.22	.21	.01	0.00	68.54	7.39	1.59	0.00	0.00	0.00	0.00	77.94
1960	.05	.02	.21	.01	0.07	33.24	5.09	2.39	1.65	0.00	.11	0.00	42.75
1961	0.00	.12	.01	.01	.16	0.00	0.00	0.00	.05	0.00	.21	1.50	2.05
1962	.15	.12	.01	.01	0.00	13.64	2.49	16.09	35.75	0.00	4.61	1.30	74.14
1963	.45	.62	.31	.11	.06	15.24	6.19	3.29	9.15	0.00	.61	.10	36.11
1964	.25	.32	.11	.01	0.00	0.00	2.39	6.39	71.15	0.00	0.00	0.00	80.61
1965	.05	.32	.11	.01	0.00	0.00	45.59	26.99	24.75	0.00	1.91	1.60	101.31
1966	1.15	.92	.81	.11	0.07	141.24	16.79	7.19	20.55	0.00	4.51	.90	194.15
1967	1.05	1.22	1.11	.71	5.06	54.54	15.29	74.39	12.65	0.00	.11	.50	166.61
1968	.65	.72	.71	.21	.06	11.14	5.09	1.69	2.65	0.00	1.91	.70	25.51
1969	.15	.72	.41	.21	0.0	58.14	171.09	7.79	8.55	0.00	6.61	.80	254.45
1970	.95	1.52	1.31	.71	.66	2.04	31.19	118.49	25.75	0.00	7.51	1.30	191.41
1971	.97	2.70	1.51	.95	3.22	152.84	92.14	15.93	45.38	0.00	4.35	.81	320.78
1972	5.39	2.85	2.04	1.26	1.07	216.65	30.[illegible]	140.51	41.69	0.00	10.30	3.49	456.14
1973	4.61	3.84	1.48	21.02	[illegible]	48.41	[illegible]	8.48	7.88	0.00	.13	2.01	134.54
1974	2.74	1.23	1.31	2.97	7.1[illegible]	[illegible].18	[illegible].74	4.31	2.6[illegible]	0.00	0.00	0.00	36.23
1975	.03	.61	.54	.22	.0[illegible]	2.0[illegible]	[illegible]	147.11	20.38	0.00	5.73	1.45	277.61
1976	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVG	1.03	1.08	.63	.63	3.0	45.2[illegible]	47.[illegible]	17.51	23.09	0.00	2.26	1.30	143.52

2000 DEPLETION LEVEL WITHOUT STA 6-3540

Table V-16. 2000 Future Without Plan Depletion Level, Station 6-3540, Cannonball River at Breien

UNITS - 1000AF

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1929	.65	.82	.51	.41	.2	130.33	20.67	2.68	27.99	0.00	0.00	.10	184.41
1930	1.25	.62	.31	.31	22.7	44.73	11.67	5.68	1.69	0.00	0.00	.10	89.11
1931	.75	.42	.31	.81	2.4	0.00	1.07	0.00	1.29	0.00	0.00	.20	7.30
1932	.05	.32	.01	.11	11.7	31.63	6.47	3.28	47.19	0.00	0.00	0.00	100.81
1933	.35	.42	.21	.21	1.2	45.53	8.27	5.38	0.00	0.00	0.00	0.00	61.62
1934	0.00	.12	.11	.01	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.23
1935	.55	.12	.01	.01	0.0	3.43	0.00	3.48	6.09	0.00	1.11	0.00	14.79
1936	.05	.12	.01	.01	.3	32.53	4.27	0.00	0.00	0.00	0.00	0.00	37.34
1937	0.00	.12	.01	.01	0.0	16.43	15.47	0.00	138.79	0.00	.71	4.90	176.93
1938	.85	.62	.41	.41	.3	20.13	1.67	.68	29.19	0.00	1.01	3.10	58.42
1939	.55	.72	.71	.21	0.0	40.93	5.67	0.9	10.39	0.00	0.00	.20	59.57
1940	.05	.22	.41	.01	0.0	5.83	14.67	16.28	0.00	0.00	4.31	.30	42.06
1941	.55	.42	.11	.01	0.0	51.[illegible]3	6.77	1.08	82.89	0.00	0.00	2.40	145.75
1942	2.05	1.02	.51	.11	.1	4.13	14.97	21.58	9.29	0.00	.31	1.10	55.22
1943	.65	.72	.21	.11	17.4	275.13	65.[illegible]7	6.38	46.59	0.00	1.81	1.40	417.02
1944	.95	2.22	.91	.61	.5	.23	195.77	7.58	82.29	0.00	1.61	1.60	294.32
1945	1.55	4.32	1.31	.81	13.0	62.33	12.67	3.78	16.19	0.00	1.21	1.20	138.42
1946	.45	.92	.81	.21	.3	13.33	2.77	0.00	2.69	0.00	0.00	.40	22.43
1947	3.55	1.42	.51	.61	24.9	52.23	56.27	3.98	54.39	0.00	.21	.30	198.42
1948	2.25	1.72	1.21	1.11	2.2	141.63	15.17	6.08	1.69	0.00	3.31	.30	176.92
1949	.35	1.52	.61	.21	0.0	106.33	128.17	17.48	6.19	0.00	2.31	.60	263.76
1950	1.25	.92	.31	.01	0.0	2.43	596.87	68.98	15.99	0.00	10.61	3.50	700.86
1951	3.25	2.52	1.81	1.61	4.0	105.73	28.57	5.28	20.39	0.00	10.91	9.10	193.22
1952	4.15	2.92	1.51	.61	1.9	4.53	427.47	11.78	8.19	0.00	4.11	4.20	470.52
1953	.95	1.22	1.01	.81	1.1	14.13	6.17	47.48	86.99	0.00	4.41	1.10	165.42
1954	1.25	1.82	1.51	.61	4.5	3.43	28.77	2.68	4.09	0.00	2.61	7.80	59.12
1955	.95	1.02	.61	.31	.0	8.33	3.97	2.08	4.19	0.00	3.01	2.30	27.02
1956	.45	.22	.01	.01	0.00	87.33	11.67	3.38	1.09	0.00	3.61	2.30	110.06
1957	.25	2.22	.91	.51	.0	0.00	2.07	7.18	43.49	0.00	2.61	1.00	60.2[illegible]
1958	1.05	1.82	1.31	.41	.2	15.63	15.87	.68	24.19	0.00	0.00	0.00	[illegible]
1959	0.00	.22	.21	.01	0.3	68.23	7.07	1.48	0.00	0.00	0.00	0.00	77.21
1960	.05	.02	.21	.01	0.0	32.93	4.77	2.28	1.49	0.00	.11	0.00	41.86
1961	0.00	.12	.01	.01	.1	0.00	0.00	0.00	0.00	0.00	.21	1.50	1.99
1962	.15	.12	.01	.01	0.0	13.33	2.17	15.98	35.59	0.00	4.61	1.30	73.25
1963	.45	.62	.31	.11	.0	14.93	5.87	3.18	8.99	0.00	.61	.10	35.22
1964	.25	.32	.11	.01	0.0	0.00	2.07	6.28	70.99	0.00	0.00	0.00	80.02
1965	.05	.32	.11	.01	0.0	0.00	45.27	26.88	24.59	0.00	1.91	1.60	100.73
1966	1.15	.92	.81	.11	0.9	140.93	16.47	7.08	20.39	0.00	4.51	.90	193.26
1967	1.05	1.22	1.11	.71	5.0	54.23	14.77	74.28	12.49	0.00	.11	.50	165.72
1968	.65	.72	.71	.21	.0	10.83	4.77	1.58	2.49	0.00	1.91	.70	24.62
1969	.15	.72	.41	.21	0.0	57.83	170.77	7.68	6.39	0.00	6.61	.60	253.56
1970	.95	1.52	1.31	.71	.6	1.73	30.87	118.38	25.59	0.00	7.51	1.30	190.52
1971	.97	2.70	1.51	.95	3.2	152.53	91.82	15.82	45.22	0.00	4.35	.81	319.89
1972	5.39	2.85	2.04	1.26	1.0	210.34	30.62	140.40	41.53	0.00	10.30	3.49	455.25
1973	4.61	3.84	1.44	21.02	20.8	48.11	15.53	8.37	7.72	0.00	.13	2.01	133.65
1974	2.74	1.23	1.31	2.97	7.1	5.88	7.42	4.20	2.47	0.00	0.00	0.00	35.34
1975	.03	.61	.54	.22	.07	1.74	99.[illegible]6	147.00	20.22	0.00	5.73	1.45	276.72
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVG	1.03	1.08	.63	.63	3.0	44.9	47.10	17.41	22.95	0.00	2.26	1.38	142.73

Remaining Needs

Energy

Because the development of coal resources is dependent on many factors both in and outside of the North Dakota planning area and the Nation, various levels of coal production were analyzed for this study. These levels or scenarios give a range of "what if" questions and answers that allow for a basis of decision.

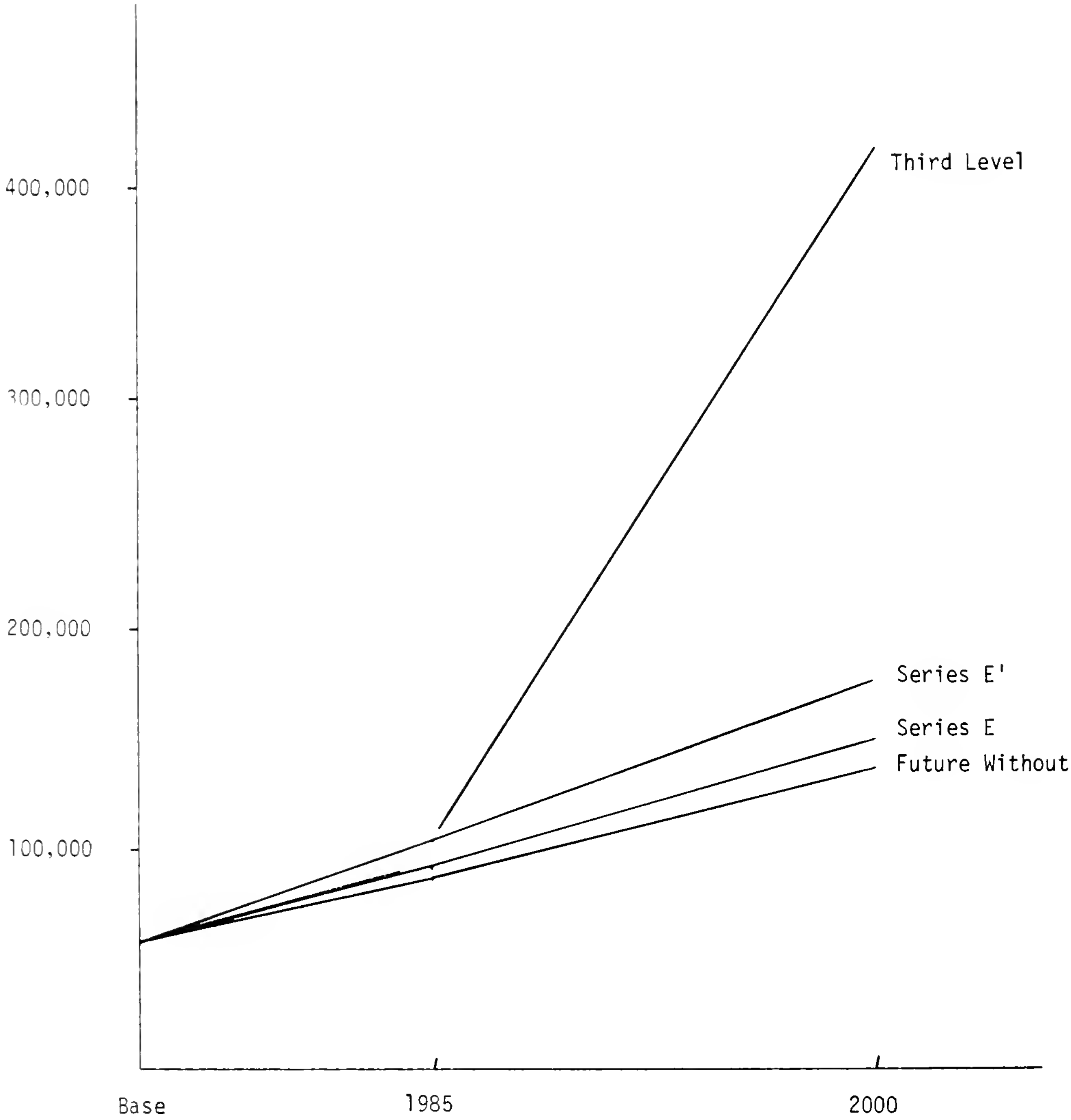
The high level energy development scenario represents that share of the business as usual demand and supply case that could be met by the Yellowstone study area considering the conservation effect of the higher energy prices and recent trends in conservation. It does not assume passage of any of the energy conservation actions currently under consideration. Current energy prices have caused approximately a 22 percent reduction from the historic growth rate. The high scenario is primarily controlled by energy demands and is the only development level that meets this region's share of the total national production as reflected under the above conditions. Under this scenario a total of 8,870 MW of electrical generation is projected. Of the total coal production the majority is projected for use in the production of synthetic gas. Associated water requirements are projected to total 115,987 AF by 1985 and 244,779 AF by the year 2000.

This level of development reflecting future demands were assumed to be met by an unconstrained private sector, therefore, the remaining needs for energy are zero.

Agriculture

Projected agricultural needs were based on OBERS series E and E' projections. In addition, a third-level projection was made in an attempt to balance OBERS livestock and OBERS crop projections. Private irrigation development was projected by the State and is shown in the future without section. The remaining needs are shown as the difference in additional irrigated acres needed to increase production to meet these needs. Series E agricultural projections indicate a total need for 90,600 cumulative irrigated acres by 1985 and 148,200 irrigated acres by the year 2000. Series E' because of the higher export assumptions show a need for 102,100

Figure V-3. ACRES REQUIRED TO MEET OBERS PROJECTIONS
USING "FUTURE WITHOUT" PROJECTED YIELDS
NORTH DAKOTA TRIBUTARIES



irrigated acres by 1985 and 177,500 irrigated acres by the year 2000. The third level projection shows a need for 102,100 irrigated acres by 1985 and 412,995 irrigated acres by the year 2000. The difference from these figures and the future without as shown in figure V-3 indicates that the maximum need for project type irrigation based on the high agricultural projection, would be 16,100 acres by 1985 and 277,995 acres by the year 2000.

Flood Control and Erosion

Flood-related problems are widespread, causing for any given area, relatively low average annual damages. Erosion damages are similar, being widespread throughout the study area. Figure V-4 shows the projected combined damages for flood and erosion damages within the planning area. Future without conditions are projected to be the same so the remaining needs are the totals as shown in figure V-5.

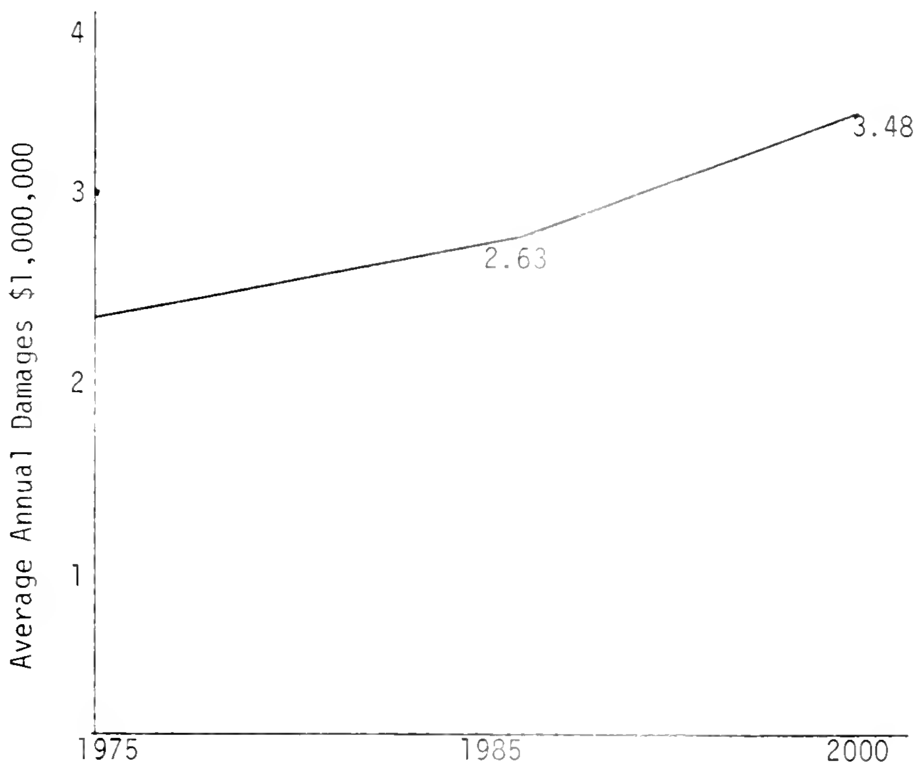


Figure V-4. Total Current and Projected Flood and Streambank Erosion Damages, North Dakota Tributaries

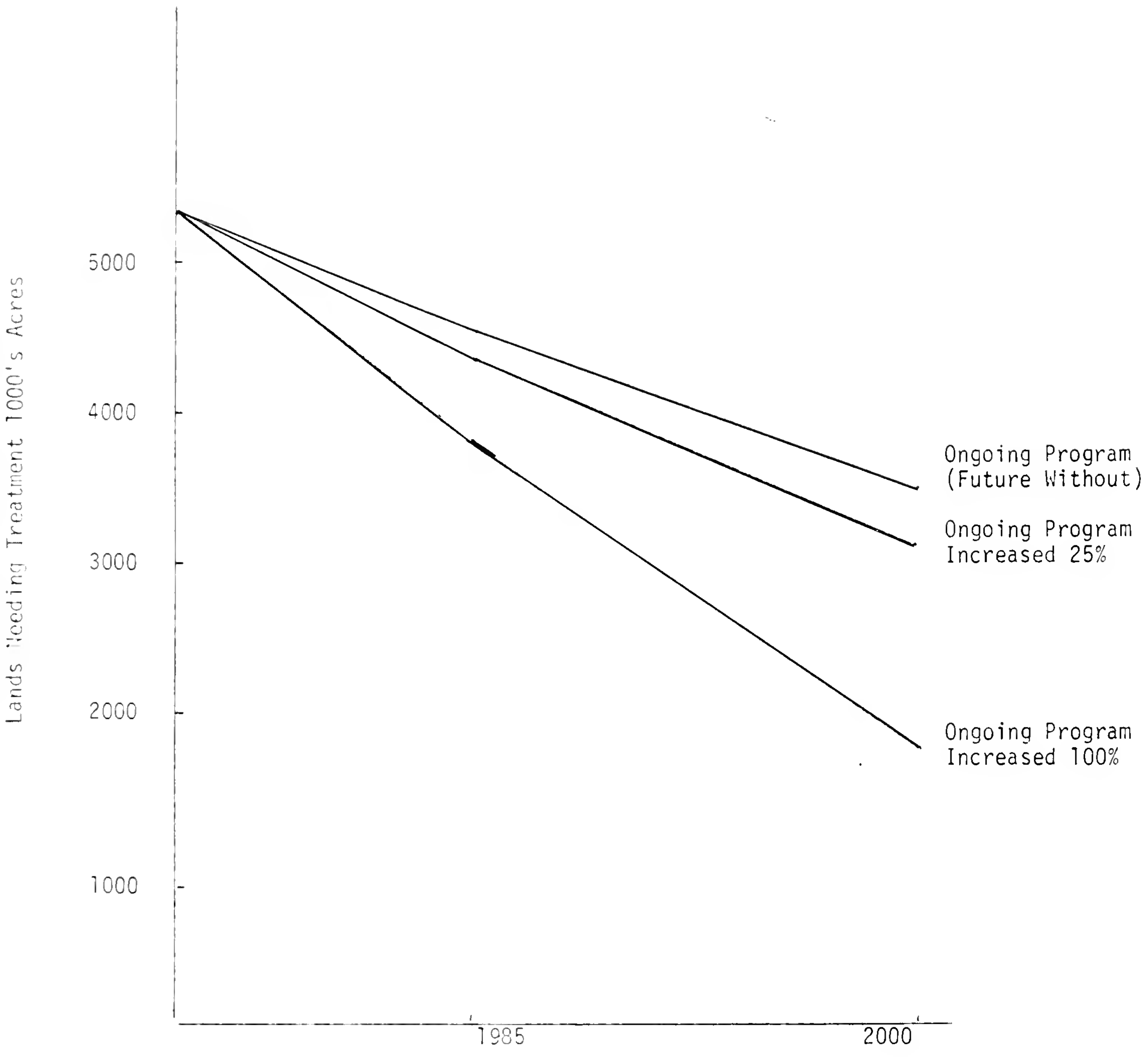


Figure V-5. Comparison of Land Conservation Alternatives
Non-Federal Land, Remaining Treatment Needs (Acres)

Land Conservation

In addition to the land conservation measures that have been projected for installation under ongoing programs, there will be sizeable areas that will not be treated there under by the year 2000. These areas are classified as "Remaining Needs" that should be evaluated to determine if it would be desirable to accelerate the installation of land conservation measures. These remaining needs should be considered for both the National Economic Development and Environmental Quality objectives. It can then be determined to what extent these needs should be accomodated in the recommended plan.

It is estimated that there will be 3,609,200 acres of land in the planning area still needing treatment in the year 2000 if there is no acceleration of the ongoing programs. This includes 33,500 acres of untreated Federal lands and 3,575,700 of non-Federal lands. A breakdown of the remaining needs by type of land use and ownership is shown in table V-17.

Outdoor Recreation

Outdoor recreation needs for nine recreation activities within the North Dakota planning area are shown in table V-18. Although very little need for additional recreation areas is indicated in table V-18 it must be recognized that the aggregate figures may not accurately reflect the needs in localized areas.

Adequacy of Existing Areas and Facilities

Beach Swimming - In total, the inventory shows there to be 25 beaches, private or public. Eleven of these are located on reservoirs and, therefore, may have the problem of water level fluctuations hindering maintenance of beaches and facilities. More "change" houses, parking facilities and improved access roads are needed. Eight of the 15 counties in the planning area have no beach areas, including six southwestern counties which are adjacent, creating a large area with no beaches.

Boating and Waterskiing - The acreage and quality of boating and waterskiing areas, for the planning region as a whole, is sufficient to meet the need. However, most of

Table V-17. Remaining Land Conservation Needs, Projected to the Year 2000

North Dakota Tributaries

Land Use and Ownership	Acres	Dollars
Nonirrigated cropland	1,584,500	87,148,000
Federal	0	0
Non-Federal	1,584,500	87,148,000
Irrigated cropland	21,500	2,482,000
Federal	0	0
Non-Federal	21,500	2,482,000
Non-irrigated Pasture	112,100	2,524,000
Federal	0	0
Non-Federal	112,100	2,524,000
Irrigated Pasture	0	0
Federal	0	0
Non-Federal	0	0
Range	1,880,500	9,184,000
Federal	33,500	2,238,000
Non-Federal	1,847,000	6,946,000
Forest-Commercial	6,400	16,000
Federal	0	0
Non-Federal	6,400	16,000
Forest-Non-commercial	4,200	30,000
Federal	0	0
Non-Federal	4,200	30,000
Other	0	0
Federal	0	0
Non-Federal	0	0
Total	3,609,200	102,384,000
Federal	33,500	2,238,000
Non-Federal	3,575,700	99,146,000

Table V-18. Outdoor Recreation Needs, North Dakota Tributaries[1/]

Activity	Activity Occasion Unit[2/]	Remaining Need					
		Base Population		Most Probable		High	
		1985	2000	1985	2000	1985	2000
Beach Swimming	Beaches[3/]	-18	-29	-25	-54	-30	-57
Water Skiing	Acres	232,317	230,321	231,740	277,612	231,295	227,345
Picnicking	Acres	634	599	606	498	585	488
Nature Walks	Miles	NA	NA	NA	NA	NA	NA
Boating/Canoeing	Acres	229,456	232,655	232,650	231,052	232,294	230,892
Camping	Acres	452	293	305	-134	214	180
Hiking	Miles	109	86	99	43	91	39
Playing Games/Sports	Acres	1,575	1,501	1,547	1,383	1,526	1,372
Winter Sports	Acres	1,101,283	1,101,278	1,101,279	1,101,264	1,101,276	1,101,262

1/ Source, Outdoor Recreation Ad Hoc Group Report, April 1977.

2/ Units as indicated are synonomous with total requirements .

3/ - indicates a need

the acreage is attributed to Lake Sakakawea, which is located on the northern boundary of the planning area, creating a prohibitive number of travel miles for the majority of the population. The next largest area is Lake Tschida, which is more centrally located but which is heavily used for powerboating, waterskiing, swimming, sailing, and fishing. These conflicting uses can cause congestion problems. More access areas and skiing drop-off points are needed separate from the beach areas.

Picnicking - Presently, most picnic tables are located near or in the smaller towns or on water recreation areas. They are quite dispersed, most counties being adequately supplied. Only 60 percent of the total demand for tables is set as a basis goal but there is also a need for replacement and maintenance of these tables and for additional tables during peak days.

Canoeing - Though included in the total number of boating acres, there are approximately 572 miles of canoeing streams in the planning area. This is adequate during the spring and early summer season when water levels are high. However, the Little Missouri, Heart, Knife and Cannonball Rivers are not canoeable during July and August. The Yellowstone and Missouri Rivers are popular all summer. Better canoeing access and parking areas are needed along these routes.

Camping - With the increase of recreational vehicles, most areas, though adequate in acreage, cannot provide enough electrical hookups, comfort stations and other support facilities. Tent areas and camping areas need to be separated. Though there is a need for more designated camping sites throughout the region, it is greatest near the water recreation areas. Most smaller towns have only general use recreation areas as opposed to designated and well managed camping sites. This can cause damage to the areas as the use increases.

Playing Games and Sports - There is an adequate supply of these areas in the region. Local school playgrounds and athletic fields also contribute towards meeting the demand.

Hiking - Though some trails are located in state parks or small towns, a large number are found in the north and south units of Theodore Roosevelt National Memorial

Park. The Little Missouri National Grasslands has many undesignated and unmaintained paths which could become part of a designated trail system. Most of the present trails are short (under two miles) and disjointed. There is a lack of a trail system, or of a significant number of trails which are a half-day or longer.

Winter Sports - This category includes sledding, cross-country skiing, downhill skiing and ice skating rinks. Many of the areas in the inventory are open space areas. Those in the southwestern corner of the planning area have very open winters but are usually not suitable for winter activities. Trails and tows need to be established, signed and maintained in designated winter sports areas.

Opportunities for Meeting Recreation Needs

There are many areas that could be expanded or improved to meet the future recreation needs. These will be discussed by recreation land types.

Type I (Historical, Scenic and Natural Areas) - The Knife River National Historic Site has only recently been designated. Though arrangements for lands surrounding the site are yet to be confirmed, basic restoration has begun. Archaeological surveys and digs have been authorized on sections of the site. This area, near Stanton, has potential for drawing tourists travelling on I-94, or visiting Lake Sakakawea.

Other areas such as Theodore Roosevelt National Memorial Park, Chateau De Mores and De Mores Packing Plant, all on the National Register of Historic Places are likely to receive significant increases in visitation. The most recent non-resident demand study showed that 75 percent of these tourists visit historic sites while in North Dakota. Also the number of nonresidents travelling through North Dakota is expected to increase. With better signing and access roads, landmarks such as Sentinel Butte and White Butte will have increased visitation. Though financial constraints inhibit the development of other historic areas, there may be eased as public demand increases.

In addition, the Nature Preserves Act of 1975 gives authorization for the preservation of significant natural areas within the State. Though no funds were

appropriated for acquisition programs, easements and other arrangements may be used.

Type II (Land Areas) - One of the greatest opportunities for recreational development is open to the private sector. It can assist in providing campgrounds and campsites needed along highways and Interstate 94, particularly near Medora. The opportunity for new recreation vehicle campgrounds, overnight and long-stay areas is great. Those areas having boat or water access would have the potential for becoming very popular camping spots.

The development of a State Trails System could greatly enhance the enjoyment of many natural areas. However, both public and private lands would need to be crossed through the use of conservation easements and/or leases. The U.S.F.S. land (Little Missouri National Grasslands) is particularily suited for a multiday hiking trail. Railroad abandonments and energy corridor areas should be investigated as possible trail areas.

Though the current political structure of the Tribal Councils of each Indian reservation exempts them from Federal monies for recreation (LAWCON Funds), they should be encouraged to develop and protect their natural, cultural, scenic and recreational areas. In addition, Ft. Berthold and Standing Rock reservation each have potential access sites to the Federal reservoirs. Fishing, hunting, boating and swimming activities have great potential in these waters.

Leasing of land from private land owners or land donations should be encouraged. Though the public ownership of land guarantees its use perpetually, money for acquisition is not always available. However, smaller towns having minimal budgets for recreation can provide areas for a fraction of the acquisition costs through leasing programs, conservation easements or donations.

Type III (Water Areas) - Lake Sakakawea could accommodate substantially more public use than it is currently receiving. Opportunity exists for additional lakeshore development and access areas. This development should include camping, picnicking,

fishing and boating access. More benevolent cost-sharing arrangements could be investigated by the Corps of Engineers to encourage this type of development on the reservoirs. In addition, private enterprise development of marinas, boat rental and docking facilities could be encouraged wherever the opportunity exists.

Continued work on legislation for a State scenic or recreational rivers classification to preserve the recreational value of the streams in the planning area is needed. In addition, better access roads and drop-off points are needed to tap the rivers current potential for canoeing, hunting, fishing and swimming use.

Better maintained access roads to public beaches will better distribute the demand in key areas. The establishment of additional beach areas on reservoirs or private lakes could be encouraged. This is especially true in the southwestern counties. Again, more satisfactory funding arrangements for recreation developments on federal reservoir land would encourage this use to occur.

Opportunities exist for all political subdivisions of the state of North Dakota to apply for outdoor recreation funds for land and water development projects. Federal assistance is available for developing recreation resources, through direct funding or other Federal assistances. Federal assistance is available through the National Historic Preservation Act of 1966 (P.L. 89-665), the Community Development Act (P.L. 93-383), the Federal Water Project Recreation Act (P.L. 89-72), and the Water Resource Development Act of 1974 (P.L. 93-251).

Nonenergy Minerals

Based on past trends private enterprise should be able to meet nonenergy mineral water demands in the future. The remaining needs are assumed to be zero for the year 1985 and year 2000.

Summary of Remaining Needs

To determine the remaining needs, the future without plan conditions from the preceding section were subtracted from the projected need or opportunity as determined in chapter IV. The remaining needs are summarized in table V-19.

Table V-[illegible]. Summary of Future without Plan and Remaining Need,
North Dakota Tributaries

Item	Existing Condition 1975	Future without Plan 1985	Future without Plan 2000	Projected Need or Opportunity 1985	Projected Need or Opportunity 2000	Remaining Need 1985	Remaining Need 2000
Streambank Erosion Damage	$ [illegible]	$ [illegible]	$ [illegible]	$ 424,000	$ 481,000	$ 424,000	$ 481,000
Knife River Indian Village	1,[illegible] feet	1,0[illegible] feet	1,[illegible] feet	---	---	---	---
Flood Damage	[illegible],41[illegible]	[illegible]	[illegible]	2,63[illegible],000	3,482,700	2,633,000	3,482,700
Hazen Flood Control	---	---	---	---	---	---	---
[illegible] water	31 impoundments	[illegible] impoundments	42 impoundments	31 impoundments	42 impoundments	0	0
[illegible] impoundments	31 impoundments	31 impoundments	42 impoundments	31 impoundments	42 impoundments	0	0
Energy, Minerals water requirement consumptive use AF	[illegible]	43	52	43	52	0	0
Wild and Recreational Rivers	Little Missouri River (South Dakota State Line to Missouri)	Little Missouri River (South Dakota State Line to Missouri)	Little Missouri River (South Dakota State Line to Missouri)	Portions of Knife, Heart, Cannonball, Yellowstone & Missouri River totaling 335 miles	Portions of Knife, Heart, Cannonball, Yellowstone & Missouri River totaling 335 miles	Portions of Knife, Heat, Cannonbal, Yellowstone & Missouri River totaling 335 miles	Portions of Knife, Heart, Cannonball, Yellowstone & Missouri River totaling 335 miles
Yellowstone River (22 mi.)	0	0	0	22 miles	22 miles	22 miles	22 miles
Knife River (76 mi.)	[illegible]	0	0	76 miles	76 miles	76 miles	76 miles
Heart River (106 mi.)	0	0	0	106 miles	106 miles	106 miles	106 miles
Cannonball River (45 mi.)	0	0	0	45 miles	45 miles	45 miles	45 miles
Missouri River (86 mi.)		0	0	86 miles	86 miles	86 miles	86 miles
Agricultural Production							
Wheat (Bu.)	41,[illegible]	44,934,700[2]	47,138,400[2]	44,71[illegible],500[1]	53,[illegible]75,300[1]	-220,200	+6,236,800
Rye (Bu.)	[illegible]	601,[illegible]	62[illegible],300	1,[illegible]	1,735,[illegible]	+677,100	+1,099,800
Corn for Grain (Bu.)	12[illegible],300	204,300	[illegible]52,100	70,000	98,100	-134,300	-154,300
Silage (Tons)	53[illegible],700	565,[illegible]	772,600	844,000	952,700	+278,200	+180,100
Oats (Bu.)	1[illegible]	[illegible]3,174,300	2[illegible]	35,3[illegible],200	51,317,700	+12,167,900	+27,825,800
Barley (Bu.)	1[illegible],1[illegible],500	1[illegible],[illegible]71,600	13,3[illegible],100	15,320,100	19,906,000	+2,657,800	+6,563,900
Hay (Tons)	1,4[illegible],000	1,377,000	1,401,500	1,764,900	[illegible],256,400	+387,900	+774,900
Soybeans (Bu.)	9,700	---	---	15,400	32,600	---	---
Flaxseed (Bu.)	52[illegible]	6[illegible]	[illegible]01,[illegible]	1,161,[illegible]	1,097,[illegible]00	+535,700	+395,800
Sugar Beets (Bu.)	115,[illegible]	205,700	352,200	132,400	162,700	-73,300	-189,500
Irish Potatoes (Cwt.)	13[illegible],100	371,400	408,[illegible]	221,200	265,300	-150,200	-143,400
Dry Beans (Cwt.)	[illegible],330	[illegible]	1[illegible],700	13,700	7,00[illegible]	-6,900	-33,700
Beef and Veal (Lbs.)	391,[illegible]	43[illegible],000	4[illegible],53,000	420,876,000	593,760,000	-17,311,000	+113,107,000
Pork (Lbs.)	2[illegible],11[illegible],000	2[illegible],638,000	19,[illegible],000	24,832,000	21,738,000	+2,194,000	+1,938,000
Lamb and Mutton (Lbs.)	[illegible]	4,[illegible]61,000	[illegible]	[illegible]	[illegible]	-1,384,000	-550,000
Chickens (Lbs.)	6[illegible]	42[illegible],000	[illegible]	704,000	317,000	+276,000	+31,000
Turkeys (Lbs.)	360,400	414,000	333,000	595,300	568,900	+181,300	+235,900
Eggs (Doz.)	2,[illegible],000	1,928,000	1,301,000	2,870,000	1,529,000	+942,000	+145,000
Milk (Lbs.)	1[illegible],230,000	1[illegible],777,000	12[illegible],000	1[illegible]7,267,000	1[illegible],142,000	+34,490,000	+13,657,000
Irrigation (Private Acres)	56,000	86,000	135,000	102,155	412,997	16,155	277,997
Energy Development							
Coal Production (Tons)	11,000,000	54,090,000	158,260,000	54,090,000	158,260,000	0	0
Thermal Electric Plant Capacity (mw)	1,22[illegible]	8,870	8,873	8,870	8,873	0	0
Gasification Plant Capacity (MMCFD)	0	250	2,524	250	2,524	0	0
Water Requirements (AF/Year)	[illegible]0,592	115,987	224,779	115,987	224,779	0	0
Instream Flow Acre-Feet							
[illegible] Grand River at Haley, ND	[illegible]	0[2]	0[3]	370- 8,540[4]	370- 8,540[4]	370- 8,540[4]	370- 8,540[4]
Cannonball River at Breien	0	0	0	9,320- 6[illegible],890	9,320- 68,890	9,320- 6[illegible],890	9,320- 68,890
Little Missouri River near Watford City, ND	[illegible]	[illegible]	0	39,490-186,330	39,490-186,330	39,490-186,330	39,490-186,330
Knife River at Hazen	[illegible]	0	0	11,820- 62,240	11,820- 62,240	11,820- 62,240	11,820- 62,240
Heart River near Mandan		[illegible]	0	16,840- 70,630	16,840- 70,630	16,840- 70,630	16,840- 70,630
Preservation (Acres)							
Unique Woodland Areas	[illegible]	[illegible]	1,93[illegible]	5,163	5,163	3,231	3,231
[illegible] Protection Sites							
Missouri River, Garrison Dam to Lake Oahe	---	21	21	21	21	0	0
Yellowstone River, Intake, Montana to mouth	---	[illegible]4	24	24	24	0	0
Hydro-Electric Power Megawatts							
Additional Hydro-power at Garrison Dam	400	400	400	672	672	272	272
Population Planning Area	[illegible],300	131,150	166,520	---	---	---	---

1/ OBERS Series E'.
2/ Source: Tables V-[illegible], V-[illegible].
3/ Instream flow for fishery or other uses not recognized as a beneficial use.
4/ Low figure is the [illegible] percent exceedance level, high figure is the modified level from the Northern Great Plains Resource Program in AF/Year.

CHAPTER VI

PLAN FORMULATION

Principles and Standards

Criteria used for the evaluation of projects and formulation of the alternative plans set forth later in this chapter are those established under the multiobjective planning (MOP) approach of the U.S. Water Resources Council. Planning guidelines for the Yellowstone Level B Study conform with the Water Resources Council's Principles and Standards for Planning Water and Related Land Resources, as published in the Federal Register of September 10, 1973.

Alternative plans for resource development and management for the North Dakota Planning Area have been formulated to emphasize national economic development (NED), and environmental quality (EQ). A third partial plan emphasizing local-State-regional development (SRD) has been included to identify projects that produce substantial local or regional benefits but do not meet NED criteria. A fourth plan, called the recommended plan, is a combination or some adjustment of those projects or programs selected from the NED, EQ, and SRD plans that best meet the needs outlined in chapter IV and are acceptable to the local people.

Plan formulation for the NED and SRD plans is tied primarily to the monetary benefit, cost and repayment evaluation of potential projects or programs (elements). The formulation criteria for retaining an element in the NED or SRD plans are that the results of the economic and financial appraisal of that element must show that user benefits exceed costs and that there is an apparent source for repayment of project costs. EQ plan formulation criteria do not relate to rigid economic standards but emphasize environmental enhancement, preservation, or management as the principal objectives. A combination of selected elements from the NED, SRD, and EQ plans makes up the recommended resource development and management plan for the North Dakota planning area as described in chapter VII.

The beneficial and adverse effects of a proposed development were evaluated for the period of its useful life, with an upper limit of 100 years using a discount rate of 6 3/8 percent. Benefits and costs occurring in different time frames over the period of analysis have been adjusted to comparable values by the use of the 6 3/8 percent discount rate. Costs and benefits are based on January 1975 prices.

The absence of governmental planning, financing, construction, and controls beyond current levels as envisioned for the "without" plan has resulted, in some cases, in levels of development that exceed any of the "with" plans. This suggests that in the opinion of the Study Team overutilization or misallocation of resources, as well as underutilization, would sometimes occur in the absence of adequate planning.

It suggests also that the recommended plan formulated on current MOP guidelines will not necessarily be the last word on future resource development and management. It is entirely possible that changes in political conditions, environmental needs, and food, fiber, and energy requirements will cause changes in resource priorities and planning criteria. It is, therefore, conceivable that unforeseen national or regional needs may be identified which could move presently unrecognized components or recognized but unjustified components to the top of the priority list.

The Four-Account System

Under the MOP procedures, each plan, regardless of which multiobjective is emphasized, is evaluated and displayed in terms of a four-account system--national, regional, environmental, and social factors. This means that each project or program proposed for consideration in any of the plans must be evaluated under the four-account system.

Benefits and costs for the national and regional accounts are expressed

as monetary values but can include a descriptive analysis of beneficial and adverse effects. For the other two accounts--environmental and social factors--the main emphasis is in identifying and evaluating changes that would occur with a plan and describing in a succinct narrative the beneficial or adverse effects associated therewith. A simplified display chart of the plans and accounts follows:

	Alternative Plan			
	NED	SRD	EQ	Recommended
National Account				
Benefits	$	$	$	$
Costs	$	$	$	$
Regional Account				
Benefits	$	$	$	$
	(--------Descriptive terms---------)			
Costs	$	$	$	$
	(--------Descriptive terms---------)			
Environmental Account				
Beneficial effects	(--------Descriptive terms---------)			
Adverse effects	(--------Descriptive terms---------)			
Social Factors Account				
Beneficial effects	(--------Descriptive terms---------)			
Adverse effects	(--------Descriptive terms---------)			

National Economic Development Account--Benefits evaluated under this account are direct user benefits. User benefits are displayed for the traditional project multiple purposes of irrigation, flood control, outdoor recreation, fish and wildlife, M&I water, power, etc. User benefits are measured as the net value to the Nation of increased outputs of goods and services resulting from a project or plan. Employment benefits may be claimed for individuals who would be unemployed or underemployed in the absence of the project. Benefits do not include second-level effects such as increased profit to businesses resulting from the project. National account costs are measured as the economic values placed on the resources required to implement a plan and place it in operation and maintain it over a 100-year period of life.

Regional Development Account--Benefits and costs evaluated under the regional account are delineated for incidence of occurrence within the boundaries of the North Dakota Planning area. These local effects generally are offset by their impact on the "rest of the Nation," because of the assumed full employment conditions (of all inputs) and the idea of transferring input productivity between regions.

Regional monetary benefits are estimated for four income categories: user benefits, induced and stemming from effects, construction impacts, and unemployment and under employment effects. User benefits are defined the same as for the national account.

Induced and stemming from effects are estimated as the income generated from implementing plan services that are in addition to user benefits. Construction impacts are estimated as the income increase accruing to the region from wage payments to imported labor forces during the construction period. Income increases to the unemployed and underemployed persons in the region are estimated as portions of the preceding two categories--induced and stemming from effects and constructions impacts--and are assumed to be significant only during the early years of project life.

Local costs include local payments toward construction and operation, and as regional tax contributions. Both adverse and beneficial effects, not evaluated monetarily, are to be measured in appropriate terms, described, and displayed in the regional account.

Environmental Quality Account--A water and land use plan may have a variety of effects--beneficial and adverse--on the environment. While monetary effects do occur and are evaluated, effects on the environment are generally characterized by their nonmarket, nonmonetary nature.

Beneficial environmental effect are contributions resulting from the management, preservation, or restoration of one or more of the desirable environmental characteristics of an area under study. Adverse environmental effects are consequences of proposed actions that result in the deterioration of relevant

desirable environmental characteristics of an area. Environmental effects are evaluated for each plan element formulated but not for individual components.

Social Well-Being Account--Beneficial and adverse effects on social well-being are derived from a plan's success or failure in meeting social needs. The identification and satisfaction of social needs will relate to the social deficiencies expected to prevail in the area "without" a plan as compared to the expected changes, social gains, or losses, "with" the plan.

The MOP guidelines for evaluating social factors were written to emphasize the effects on those potential users of projects or programs who have, without the project or program, failed to share in rising economic standards. This would seem to focus on the unemployed or underemployed persons who, according to regional benefit evaluation criteria, would be significant in number only during the early years of project life because of the assumed long-range, reasonably full employment situation nationally.

Procedures are not available to measure the social status of future beneficiaries. Opportunities for improving social status are available through implementation of resource development; however, documentation of the actual benefiting social groups is difficult. Social effects are, therefore, evaluated and displayed only for the projects and programs that are included in the alternative plans, and are not considered as an end in themselves.

Display of Data--To provide consistancy in the display of information for various projects and programs that have been analyzed, data have been set forth in the general format suggested by figure VI-1. In some cases the form itself has been used, in other cases separate sheets have been used for each account, but the arrangement and coverage is the same in either case.

Project Formulation

When data for a project or program that has been suggested for inclusion in the planning area has been evaluated and tabulated under the four-account

Implementation Agency/Authority

(1) Source of Information:
Completed by:
Date Completed:
Reference Documents:

BENEFICIAL EFFECTS [illegible]

[illegible]
Irrigation
[illegible]
Fish and wildlife
Power
[illegible]
Navigation
Water quality
Unemployment and underemployment
Externalities

Total beneficial effects:
average annual equivalent value.

ADVERSE EFFECTS

Installation cost
Interest during construction
Annual investment cost
Annual OM&R
Total annual cost
External diseconomies
Total adverse effects:
average annual equivalent value

NET BENEFICIAL EFFECTS

	Region	Adjacent Region	Rest-of-Nation

BENEFICIAL EFFECTS

User benefits:
Irrigation:
Municipal and industrial water
Flood:
Fish and wildlife:
Outdoor recreation
Power:
Hydro
[illegible]
Navigation
[illegible]

ENVIRONMENTAL QUALITY ACCOUNT

(8) BENEFICIAL EFFECTS

Areas of natural beauty and human enjoyment

Biological, geological and ecological elements:
Water quality:
Air quality:

(9) ADVERSE EFFECTS

Areas of natural beauty and human enjoyment lost:
Archeological, historical, and cultural elements lost.
Irreversible considerations:

Water quality
Air quality:

SOCIAL WELL-BEING ACCOUNT

(13) BENEFICIAL EFFECTS

Stabilized population:
Distribution of income:
Increased recreation days:
Increased fish and wildlife days:
Increased employment:
Skilled
Semi-skilled

Stabilization of economic conditions:

(14) ADVERSE EFFECTS

Population impacts:
Local facilities
Moving of people

1/ Ad valorem taxes, user payments for both regions.
2/ Difference between total investment and footnote 1/

system, it is then possible and necessary to test the proposal in terms of its acceptabilities for inclusion in the various "objective" plans--National Economic Development (NED); State-Regional Development (SRD); and environmental quality (EQ). Each of these plans has specific requirements that must be met if a project or program is to be included in that plan, and to the extent that this is so, the proposal's attractiveness for inclusion in the Recommended Plan (RP) is enhanced. The RP is a selection or adjustment of those components of the other three plans that best satisfies the needs identified in chapter IV. No project or program may be included in the Recommended Plan unless it has qualified for at least one of the three objective plans or was adopted from the future without plan. A more detailed description of each of the projects or programs discussed in the NED and EQ plan and of the SRD elements can be found in appendix 6a, section III, part C of this study team report.

National Economic Development Plan

National economic development is achieved by increasing the value of the Nation's goods and services, through the use of additional resources or by improving the efficiency of existing resource use. Theoretically, the best NED plan will produce the maximum net benefits (excess of projected monetary benefits over monetary costs). A satisfactorily developed plan with NED emphasis will meet the following minimum requirements.

1. User benefits are in excess of total economic costs;
2. Separable costs of each functional component are less than benefits or, the alternative cost of producing comparable benefits;
3. Sufficient capability is available to repay all reimbursable costs;
4. Significant local and State support is available; and
5. Output from the plan will be used to meet near-to-intermediate-term needs.

A project or program may not be included in the NED plan unless it meets all of the above requirements.

National Economic Development Plan Elements

Requiring Additional Government Action

Multipurpose Projects

Cannonball Division Alternative [29/] No. 1; Cannonball Unit. Cannonball Dam would be of rolled earthfill construction with a crest length of 8,200 feet at elevation 2,284. There would be three dikes with a combined length of 5,600 feet, with crest elevation 2,284. The glory-hole-type spillway, with crest elevation 2,226, would have a maximum capacity of 3,478 cubic feet per second. The outlet works would have a capacity of 227 cubic feet per second at water surface elevation 2,187.

The conservation pool of 78,000 AF would be used for irrigation, municipal, and industrial water. Water would be released as required during the irrigation season, and pumped from the stream to laterals serving the scattered parcels of irrigated lands. The erratic runoff and long-term storage require large capacities in relation to average annual releases for irrigation purposes. A total of 5,000 acres of land could be served. In addition, a flood control capacity of 163,000 acre-feet would be provided. Some 19,000 AF of municipal and industrial water would be provided for use by towns, rural farmers or industrial plants.

Cannonball Division Alternative [29/] No. 1; Thunderhawk Unit. Thunderhawk Dam would be of rolled-earth construction with a crest length of 10,970 feet at elevation 2,408.8. The spillway would be of the ungated drop-inlet-type with a crest elevation of 2,357.3 and a maximum capacity of approximately 85 cubic feet per second. The conservation pool of 43,400 acre-feet would be used for irrigation, municipal, and industrial water. The erratic runoff and long-term storage require large capacities in relation to average annual releases for irrigation purposes. It would serve 2,400 acres. In addition, 210,000 AF of flood control capacity would be provided. Eleven thousand AF of municipal and industrial water would be provided for use by towns, rural farmers, or industrial plants.

Broncho Dam and Reservoir Alternative.[29/] Under this plan, the Broncho Dam and reservoir would be used as a water supply for municipal, rural, and industrial water as well as providing water for 4,000 acres of irrigation. Minimum fish and wildlife facilities and recreation facilities would also be provided. The dam would be a rolled earthfill embankment with a maximum height of 124 feet above streambed at a crest elevation of 1,990 and a length of 9,450 feet. The outlet works to the Knife River would have a capacity of 1,000 cfs. For gravity service to adjacent downstream lands, two canal outlet works would be provided with capacities of 15 and 45 cfs through the right and left abutments respectively. Conservation storage would be 55,000 acre-feet and flood control storage would total 40,000 acre-feet. Fifteen thousand acre-feet would be used for municipal, rural, and industrial water, and the remainder would be used to irrigate 5,000 acres of land. Four river pumping plants would be required to divert water from the Knife River to irrigable lands.

Energy Development - NED Scenario

To meet NED criteria, the "high" level demand from the Harza report was modified to remove all coal gasification and to preclude the slurry of North Dakota lignite until the year 2000 (table VI-1). The reasons for these changes were that the coal gasification in the original high level scenario was not included because of its economic feasibility but rather was an add on. The reason for removing the 1985 North Dakota coal slurry from the original high scenario was because of some evidence that North Dakota lignite cannot be slurried using present technology and, also, some legal question as to the possibility of water for slurry purposes being recognized as a beneficial use in North Dakota under existing water laws. Therefore, the judgment was made to not allow slurry of North Dakota lignite until the year 2000 under the above

29/ The Alternative's were selected from reservoirs of the same location but with differing water uses. See Appendix 6a, for details of the other Cannonball and Broncho plans.

Table VI-1. [illegible] Energy Development Scenario
Estimated Resource Requirements
And Air Pollutant Emissions
North Dakota Tributaries

Item		1985	2000
Coal Production	Million tons/year	20.71	164.88
Thermal Electric Plants			
Megawatt Capacity	Megawatts	8046	8873
Gigawatt-hour/year	Gigawatt	28333	40806
Coal Consumption			
Study Area Generation	Million ton/year	20.71	28.34
Export	million ton/year	0	136.54
Water Requirement 1/			
Mines	Acre-feet/year	414	3298
Reclamation	" " "	3085	24568
Electric Generation	" " "	70832	102015
Slurry Pipeline	" " "	0	80743
Total	" " "	74331	210628
Labor Requirements 2/			
Mines	Man-years/year	421	3904
Electric Generation	" " "	1046	1153
Total		1467	5058
Capital Requirement			
Mines	Million dollars	84	1263
Electric Generation	" "	2241	2508
Total	" "	2325	3770
Land Requirements			
Strip Mining	Acres/year	793	6315
Sites	Acres		
Mines		621	4946
Electric Generation		8046	8873
Total		8667	13819
Air Pollutant Emissions			
Particulates	Tons/year	14166	20403
Sulfur Oxides	" "	169996	244835
Nitrogen Oxides	" "	141663	204029

1/ Consumptive use

2/ Operating Personnel only.

scenario. The resulting energy development scenario then selected for the NED plan shows a coal production of 20.71 million tons by 1985 and 164.88 million tons by the year 2000. This coal production would be processed as follows: electrical generation 20.71 million tons for the year 1985, and 136.54 million tons export and 28.34 million tons for electrical generation for the year 2000.

Flood Control

A structural flood control measure was evaluated for protecting the city of Hazen from the damages that occur as a result of flooding from Antelope Creek. This was the only flood damage location that justified a structural measure under the NED criteria.

National Wild and Scenic River System

The 86-mile reach of the Missouri River from Garrison Dam to Fort Lincoln State Park was identified as possessing values that would make it eligible for addition to the National Wild and Scenic Rivers System. The river and its environment offer visitors recreation opportunities in fishing, hunting, camping, picnicking, sight-seeing, canoeing, and other water-related activities. The plan includes acquisition of land in fee title for 16 acres and easement for 18,920 acres. With the construction of the proposed additional hydro-electric power units at Garrison Dam and the proposed re-regulation dam this proposed recreation river would be reduced by 11 miles. With this reduction in length the required easement would be reduced from 18,920 acres to 16,500 acres.

Hydroelectric Power

The tentative proposal is to construct additional hydroelectric power units at Garrison Dam. Three new units would have an installed capacity of 272 megawatts and would cost about $70 million. A westward extension of the existing powerhouse would utilize three modified flood control tunnels, thereby permitting a large saving in construction costs. The plan proposed would include a re-regulation dam about 11 miles downstream of Garrison Dam, upstream of the confluence with the Knife River, and will reduce the length of the State recreation river proposed herein from 86 miles to 75 miles.

National Economic Development Plan Elements From the Future Without Plan

BLM Impoundments

The BLM has 31 existing impoundments in the area and 11 more are predicted to be constructed by the year 2000 under this ongoing program. These projects from the "future without plan" are included in the NED plan.

Private Irrigation Development

A total of 86,000 acres of privately irrigated land by 1985 and 135,000 acres by the year 2000 was included in the NED from the future without plan.

Non-Energy Minerals

A total consumptive use of 43 AF by 1985 and 52 AF by the year 2000 was projected for development of nonenergy minerals in the North Dakota area. This required water supply is expected to follow past trends of private development and was adopted in the NED plan from the future without plan.

Agricultural Production

The levels of agricultural production as shown in the future without plan (tables V-2, V-3, and V-4) were adopted for the NED plan.

Land Conservation

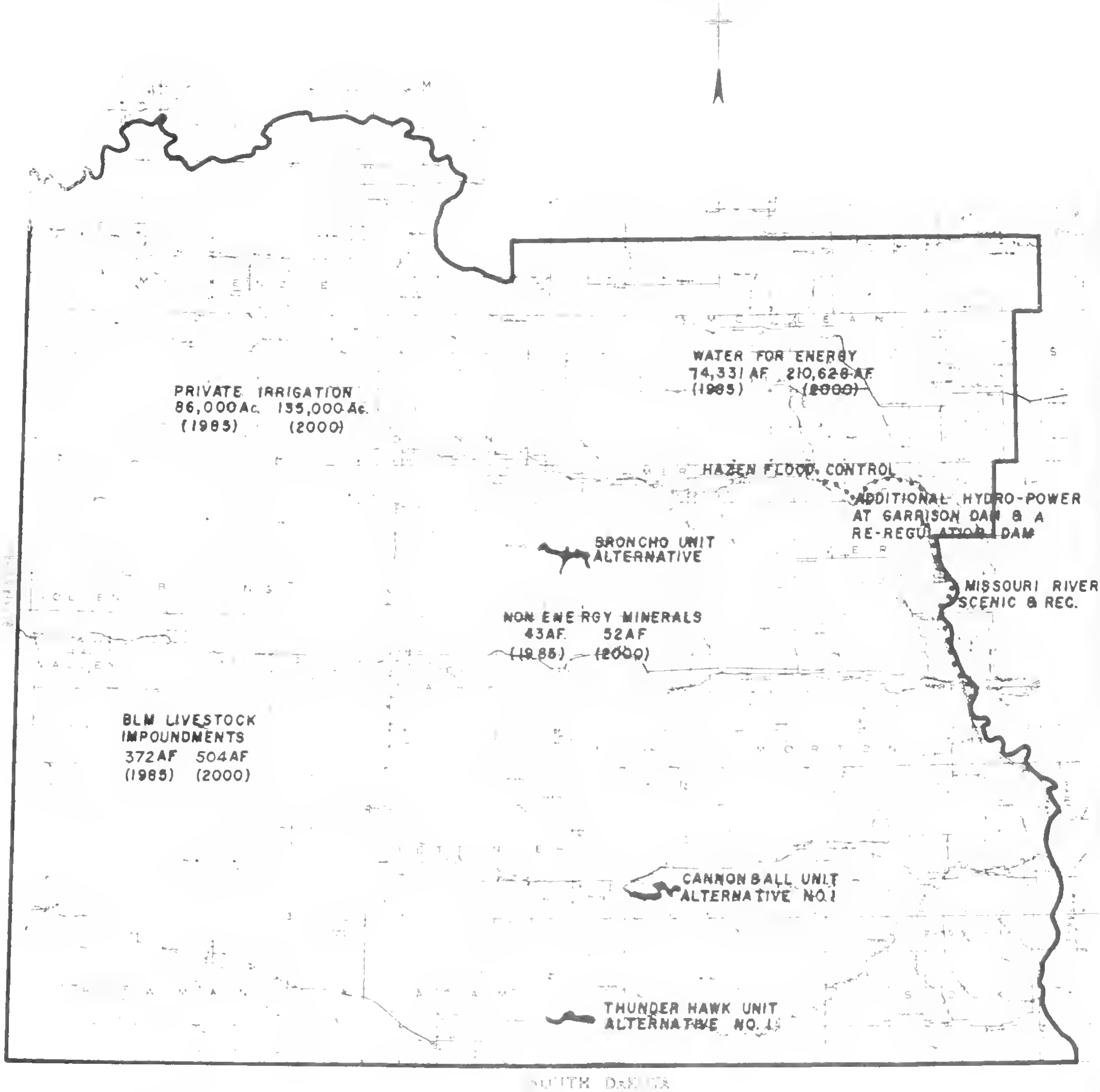
The ongoing level of the land conservation program of the SCS was adopted from the future without plan for inclusion in the NED plan. Under this ongoing program it has been projected that an additional 1,115,200 acres will be treated in the North Dakota planning area by 1985 and by 2,162,400 acres by 2000. Of this 413,000 acres are Federal lands and 1,749,200 acres are non-Federal lands.

Beneficial and Adverse Effects of NED Plan Elements

The beneficial and adverse effects of the NED plan elements are shown in table VI-2. These brief descriptions of the effects were taken from the more detailed descriptions that were used during the plan formulation process. The general location of each NED plan element is shown on figure VI-2.

Figure VI-2

NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN NORTH DAKOTA TRIBUTARIES



OTHER ELEMENTS OF THE NATIONAL ECONOMIC DEVELOPMENT PLAN

A. ON GOING LAND CONSERVATION PROGRAM
B. PROJECTED LEVELS OF AGRICULTURE PRODUCTION

YELLOWSTONE BASIN AND ADJACENT COAL AREA LEVEL B STUDY
MISSOURI RIVER BASIN COMMISSION

Table VI-2. Display of Beneficial and Adverse Effects - [illegible] Plan, North Dakota Tributaries

Plan Function Element	National Economic Development	Environmental Quality	[illegible]	Social Well-Being
FLOOD CONTROL				
Hazen Flood Control (provides Hazen protection from flooding of Antelope Creek)	Capital Costs Annual Benefits $40,000 Annual Adverse Effects $17,100	Air pollution increased slightly during project construction. Channel relocation will cause a temporary increase in downstream bank erosion	Annual Benefits $4[illegible] Annual Adverse Effects $ 7,209	Create 1[illegible] skilled jobs for 36 days and [illegible] man-days of part time employment for local residents each year. Provide an estimated 95 [illegible] reduction of flood damages to the flood plain
ENERGY DEVELOPMENT				
NED Energy Development Scenario (coal production of 20.71 million tons/year by 1985 and 164.88 million tons/year by 2000)	Capital Costs $3,770,000,000 Annual Benefits $584,500,000 Annual Adverse Effects $497,240,000	Energy related facilities will impose long-term obtrusions to the visual quality of the area. Anticipated increases in major facilities from 1975 to 2000 include an addition of 6,359 megawatts. Land requirements for these facility sites will total 8,873 acres in the year 2000 and 4,946 acres for mine sites. Strip mining will affect 6,315 acres/year in 2000. Areas surrounding and downwind of energy conversion plants will be subjected to low levels of aerial contaminants over a long period of time. The value of the reclaimed lands will be dependent on the level of success of the reclamation program. Water requirements will total 210,628 AF/year in 2000.	Annual Benefits - Not available Annual Adverse Effects - Not available	Not available

Table VI-2 (Cont.). Display of Beneficial and Adverse Effects - NED Plan, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Environmental Quality	Regional Development	Social Well-Being
SCENIC AND RECREATION RIVER				
Missouri River (75 miles of free-flowing stream below Garrison Dam)	Capital Cost $11,806,000 Annual Benefits $1,237,500 Annual Adverse Effects $1,108,595	Maintain scenic, recreation and wildlife options by preservation of 75 miles of free flowing streams from 11 miles downstream of Garrison Dam to the mouth of the Heart River at Fort Lincoln State Park.	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be regulated by purchase of 16 acres in fee title and 16,500 acres of easement
BLM IMPOUNDMENTS				
BLM Impoundments (11 additional impoundments under ongoing program)	Assumed at least equal to cost	Provides better utilization of range	Not Available	Not Available
PRIVATE IRRIGATION				
86,000 Acres by 1985 135,000 Acres by 2000	Assumed at least equal to cost	Irrigation development could provide better interspersion of food and cover for wildlife. Streamflows would be somewhat depleted and water quality decreased. Irrigation is projected to reach 86,000 acres by 1985 and 135,000 acres by the year 2000	Assumed to exceed cost	Irrigation would help stabilize rural population
MULTIPURPOSE PROJECTS				
Cannonball Unit Alternative No. 1 (dam and reservoir on Cannonball River providing water for 5,000 acres of new irrigation, 163,000 AF of flood control storage, and 19,000 AF annually for municipal, industrial, and rural use)	Capital Cost $20,254,000 Annual Benefits $4,367,000 Annual Adverse Effects $1,631,500	Reservoir of 3150 acres (conservation level) would be created. Reservoir fishery created and slight improvement in fishery in the river below dam. Irrigation development could provide better interspersion of food and cover for pheasants. Visual	Annual Benefits $5,479,000 Annual Adverse Effects $1,825,500	Slight redistribution of income, flood control would be provided additional recreation areas would be provided. With associated industrial development local population could increase. For a four year period construction population would total 225 persons with an estimated 77 school children

[illegible] North Dakota [illegible]

[illegible]	National Economic Development	Environmental Quality	[illegible]	[illegible]
M[illegible] Cannonball Unit Alternative [illegible]		quality from irrigation facilities would be reduced. Several mile of free flowing stream would be impounded. There would be heavy sedimentation on the reservoir.		
[illegible]hawk Unit Alternative [illegible]	Capital Cost $1[illegible] [illegible] 1,[illegible],000	reservoir of 31[illegible] acres at conservation level would be created. Reservoir fishery created and slight improvement in fishery in the river below dam. Irrigation development would provide better interspersion of [illegible] and cover for pheasants. Visual quality from irrigation facilities would be reduced. Several mile of free flowing stream would be impounded. There would be heavy sedimentation in the reservoir.	Annual Benefits [illegible] Annual Adverse Effects [illegible]	[illegible] with [illegible] industrial [illegible] increase [illegible] population [illegible] 1[illegible] persons with an estimated 5[illegible] school children for a four year period.
Broncho Dam and Reservoir [illegible] reservoir on the Knife River providing water for 5,000 acres of new irrigation, 40,000 AF of flood control storage and 15,000 AF annually for municipal, industrial, and rural use)	Capital Cost $34,014,000 Annual Benefits $[illegible],511,000 Annual Adverse Effects $2,599,000	Up to 4650 acres would be inundated by the reservoir. Visual quality from irrigation facilities would be reduced. Several miles of free-flowing stream would be impounded. There would be heavy sedimentation in the reservoir. Fishing below the dam would be slightly improved.	Annual Benefits $[illegible],6[illegible],000 Annual Adverse Effects $[illegible],712,000	Irrigation would help stabilize rural population. Construction over a 5-year period would increase population by 250. 23,000 acres would be provided for flood protection. Additional recreation areas would be provided. Associated industrial development would increase the population by 200 people. An es-

Table VI-2 (Cont.). Display of Beneficial and Adverse Effects - NED Plan, North Dakota Tributaries

Plan Function/Element	Account			
	National Economic Development	Environmental Quality	Regional Development	Social well-Being
MULTIPURPOSE PROJECTS (CONT.)				
Broncho Reservoir Alternative (Cont.)				timated 280 school children would be added to local schools. Irrigation and dam related works would affect some lands where owners would not receive any benefits from the project
HYDRO-ELECTRIC POWER				
Additional Hydroelectric power at Garrison Dam	Capital Costs $70,000,000 Annual Benefits $9,579,000 Annual Adverse Effects - $4,790,000	Increased river stage fluctuations downstream from Garrison Dam. Loss of about 190 acres of terrestrial habitat bordering the river due to a one-time bank slope adjustment. This loss will be mitigated by acquisition of 285 acres of similar habitat.	Annual Benefits - Not Available Annual Adverse Effects - Not Available	Retail and service activities stimulated by construction employment of 290 persons. Value of housing temporarily inflated in nearby communities. OM&R employment of 5 persons added.
NON-ENERGY MINERALS				
Non Energy Minerals (sand, gravel, clay, others)	Assumed at least equal to cost	Not Available	Not Available	Not Available
AGRICULTURAL PRODUCTION				
Agricultural Production (future without level)	Assumed at least equal to cost	Not Available	Assumed to exceed cost	Not Available
LAND CONSERVATION				
Continue Ongoing Program	Assumed at least equal to cost	An additional 1,115,200 acres of land would be treated by 1985, increasing to 2,162,400 acres by the year 2000.	Assumed to exceed cost	Provide additional employment on the application and maintenance of proposed measures.

Environmental Quality Plan

The objective of the EQ plan is the management, conservation, preservation, creation, restoration, or improvement of natural and cultural resources and ecological systems in the area under study. Although the EQ plan is not subjected to a benefit/cost comparison as such, the plan should reflect the most efficient way of obtaining the desired results.

Primary consideration is given to environmental protection or enhancement utilizing those unique or natural resources of the area where they exist. A measure of their importance would recognize the available supply at the local, regional, and national level. Consideration for the preservation of those resources that are scarce or irreplaceable should be given a high priority.

Environmental Quality Plan Elements Requiring Additional Government Action

Energy Development - Environmental Quality Scenario

It was recognized that the development of coal resources within the North Dakota Tributaries planning area does not enhance the environment; however, the EQ energy scenario as adopted is a modification of the "low" level Harza scenario that recognizes those plants that have been or are now (1977) under construction in the area. These plants total 2,513.9 megawatts of electrical generating capacity requiring a total of 19 million tons of coal production per year (table VI-3). The estimated resource requirements and air pollutant emissions for the scenario are shown in table VI-4. Additional conditions for including these units in the EQ plan were: intensified land reclamation through stricter reclamation laws, energy conservation, and the phase-out of these units at the end of their plant life or that of the associated coal mine, whichever occurs first. With minor exceptions the plant life would extend beyond the year 2000.

Table VI-3. Environmental Quality Energy Development Scenario
Plant Location and Estimated Coal Use (1985)
North Dakota Tributaries

System1/	Plant Name and Location	Megawatts2/	Coal Use Tons/Year3/	Mining Operator
BEPC	Leland Olds, Stanton	652	4,000,000	Consolidation
UPA	Stanton	172	1,000,000	North American
MPC	Milton R. Young, Center	234	1,500,000	Baukol-Noonan
MDU	Heskett, Mandan and Dakota and Knife River, Beulah	115.9	1,500,000	Knife River
MDU	Big Stone (1)	---	2,500,0004/	Knife River
MPL	Milton R. Young, Center	440	2,800,000	Baukol-Noonan
UPA				
CPA	Coal Creek, Falkirk	900	5,700,000	North American
		2513.9	19,000,000	

1/ BEPC - Basin Electric Power Cooperative
UPA - United Power Association
MPC - Minnkota Power Cooperative, Inc.
MDU - Montana-Dakota Utilities Co.
MPL - Minnesota Power & Light Company
CPA - Cooperative Power Association

2/ Source, North Dakota State Water Commission, May 1977.

3/ Source, North Dakota Public Service Commission, January 1977

4/ Exported

Table VI-4 . EQ Energy Development Scenario
Estimated Resource Requirement and
Air Pollutant Emissions
North Dakota Tributaries

		1985	2000
Mines	Total Number	6	6
Coal Production	Million tons/year	19	19
Thermal Electric Plants	Total Number	6	6
Megawatt Capacity	Megawatts	2513.9	2499.3 3/
Gigawatt-hour/year	Gigawatt-Hour/year	15434	15342
Water Requirements 1/			
Mines	Acre-feet/year	380	380
Reclamation	" " "	2831	2831
Coal Gasification	" " "	0	0
Electric Generation	" " "	38587	38357
Slurry Pipeline	" " "	0	0
Total	" " "	41798	41568
Labor Requirements 2/			
Mines	Man-Years/year	130	130
Coal Gasification	" " "	0	0
Electric Generation	" " "	186	186
Total	" " "	316	316
Capital Requirements			
Mines	Million Dollars	92	92
Coal Gasification	" "	0	0
Electric Generation	" "	437	437
Total	" "	529	529
Land Requirements			
Strip Mining Area	Acres/Year	728	728
Sites			
Mines	Acres	570	570
Coal Gasification	"	0	0
Electric Generation	"	2517	2502
Total	"	3815	3800
Air Pollutant Emissions			
Particulates	Tons/Year	7717	7671
Sulfur Oxides	" "	92604	92052
Nitrogen Oxides	" "	77170	76710

1/ Consumptive use

2/ Operating personnel only; construction employment is expected to peak in about 1978 under this scenario at an estimated 2,750 construction workers, with a zero population impact over natural growth for 1985 and 2000.

3/ 14.6 MW, generating unit to be permanently removed from any service in mid-1985. MARCA Report Pursuant to FPC Order No. 383-4, Docket No. R-362, Appendix A-1, April 1, 1977.

Streambank Erosion Control

The Knife River Indian Villages National Historic Site near Stanton, North Dakota, is located near the confluence of the Knife River and the Missouri River. A streambank erosion problem affects the Knife River at the Sakakawea site.

State Recreation River System

Yellowstone River - North Dakota - Montana State line to Missouri River. This river reach totaling approximately 22 miles was identified as possessing values that should make it eligible for addition to a State Recreation Rivers System. The plan includes acquisition of 8 acres in fee title and 4,480 acres of easement.

Knife River - Manning, North Dakota to Missouri River. This river reach totaling approximately 76 miles was identified as possessing values that should make it eligible for addition to a State Recreation Rivers System. The plan includes acquisition of 76 acres in fee title and 16,720 acres of easement.

Heart River - Heart Butte Dam to Missouri River. This river reach totaling approximately 106 miles was identified as possessing values that should make it eligible for addition to a State Recreation Rivers System. The plan includes acquisition of 76 acres in fee title and 23,320 acres of easement.

Cannonball River - County Road South of Shields to North Dakota Bridge 1806. This river reach totaling approximately 45 miles was identified as possessing values that would make it eligible for addition to a State Recreation Rivers System. The plan includes acquisition of 68 acres in fee title and 9,900 acres of easement.

Missouri River - Garrison Dam to the mouth of the Heart River, Fort Lincoln State Park. This reach totaling approximately 86 miles was identified as possessing values that should make it eligible for addition to the National Wild and Scenic Rivers System. The river and its environment offer visitors recreation opportunities in fishing, hunting, camping, picnicking,

sightseeing, canoeing, and other water-related activities. The plan includes acquisition of land in fee title for 16 acres and easement for 18,920 acres.

Private Irrigation Development

The level of existing development totaling 56,000 acres of private irrigation development was adopted for inclusion in the EQ plan. Government action would be required to limit development at this level.

Unique Woodland Areas

This proposal provides for the protection and management of 4,328 acres of ponderosa pine, 735 acres of limber pine, and 100 acres of columnar juniper and adjacent areas by administrative action on Federal lands and through acquisition of easements on private lands. The 735 acres of limber pine are located in western Slope County of which 532 acres are in Federal ownership and 203 acres are privately owned. No other native stands are found in North Dakota or Eastern Montana. About 4,328 acres of ponderosa pine are found along the Little Missouri River, of which 1,932 acres are federally owned and 3,028 acres are privately owned. This is the only native ponderosa pine in North Dakota. A small stand of columnar juniper is located in the proximity of the Burning Coal Vein northwest of Amidon, North Dakota occupying 100 acres, all in Federal ownership. The plan calls for easement acquisition on 3,231 acres of private lands.

Instream Flow

The modified levels of instream flow of table IV-II were selected for inclusion in the EQ plan. Because instream flow is not recognized legally as a beneficial use in North Dakota at the present time, modification of the State water laws would be required to attain this objective.

Environmental Quality Plan Elements From The Future Without Plan

BLM Impoundments

The BLM has 31 existing impoundments in the area and 11 are predicted to be

added by the year 2000 under this ongoing program. These projects from the "future without plan" are included in the EQ plan.

Agricultural Production

The levels of agricultural production as shown in the future without plan (tables V-2, V-3, and V-4) were adopted for the EQ plan.

Land Conservation

The ongoing level of the land conservation program of the SCS was adopted from the future without plan for inclusion in the EQ plan. Under this ongoing program it has been projected that an additional 1,115,200 acres will be treated in the North Dakota planning area by 1985 and 2,162,400 acres by 2000. Of this total 413,200 acres are located on Federal lands and 1,749,200 acres are non-Federal lands.

Beneficial and Adverse Effects of EQ Plan Elements

The beneficial and adverse effects of the EQ plan elements are shown in table VI-5. These brief descriptions of the effects were taken from the more detailed descriptions that were used during the plan formulation process. The general location of each EQ plan element is shown on figure VI-3.

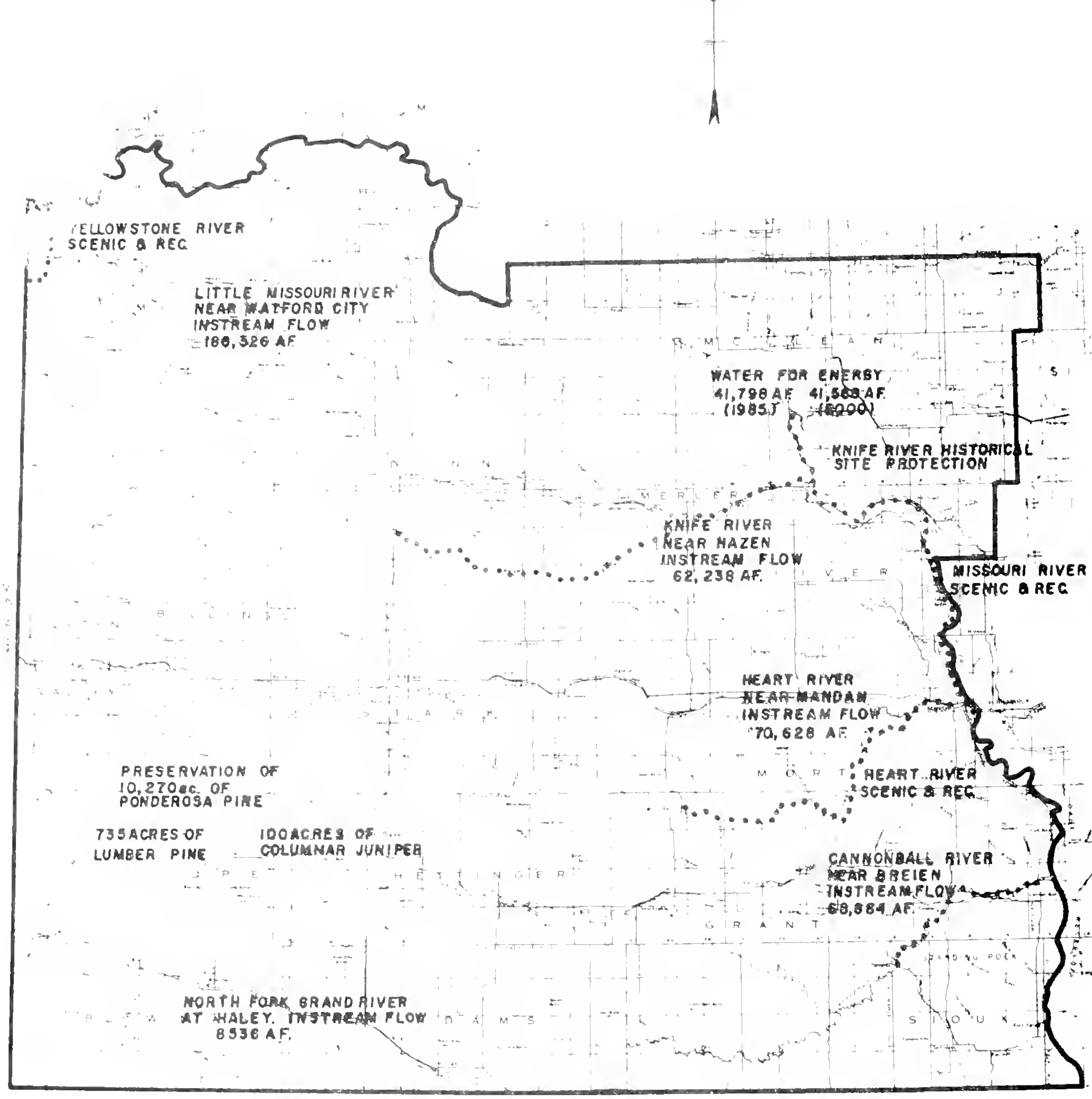
State-Regional Development Elements

Local development is accomplished by utilizing available local, regional, and national resources to alleviate chronic or cyclic economic conditions of low income, high unemployment, or other persistent economic or social problems within the region, but only in those cases where there is a known or reasonable predictable sources of financing for the costs associated with non-national benefits. An acceptable plan with SRD emphasis will provide:

1. Monetary benefits (user benefits plus other regional benefits) must exceed national economic costs;
2. Sufficient repayment capability is available to meet cost-sharing requirements; and

Figure VI-3

ENVIRONMENTAL QUALITY (EQ) PLAN NORTH DAKOTA TRIBUTARIES



OTHER ELEMENTS OF THE ENVIRONMENTAL QUALITY PLAN

A. ONGOING LAND CONSERVATION PROGRAM
B. PROJECTED LEVELS OF AGRICULTURE PRODUCTION
C. EXISTING (1975) 56,000 ACRES OF IRRIGATION DEVELOPMENT
D. BLM LIVESTOCK WATER IMPOUNDMENTS

YELLOWSTONE BASIN AND ADJACENT COAL AREA LEVEL B STUDY
MISSOURI RIVER BASIN COMMISSION

Table VI-5. Display of Beneficial and Adverse Effects - EQ Plan, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Account: Environmental Quality	Account: Regional Development	Account: Social Well-Being
STREAMBANK EROSION				
Knife River Historic Site Protection	Capital Cost $105,000 Annual Benefits $0 Annual Adverse Effects $6,973	Preserve an irreplaceable archeological resource and restore the natural setting of the period of historic importance	Annual Benefits $0 Annual Adverse Effects -	Minor amount of increase in local employment during project construction
ENERGY DEVELOPMENT				
EQ Energy Development Scenario (coal production of 19 million tons/year by 1985 and 2000)	Capital Cost $529,000,000 Annual Benefits $181,500,000 Annual Adverse Effects $154,420,000	Energy related facilities impose long term obtrusions to the visual quality of the area. Strip mining will affect 728 acres/year by 2000. Areas surrounding and downwind of energy conversion plants will be subjected to low levels of aerial contaminants over a long period of time. The value of the reclaimed lands will be dependent on the level of success of the reclamation program. Water requirements will total 41,568 AF/Year by the year 2000.	Annual Benefits - Not Available Annual Adverse Effects - Not Available	Not Available
SCENIC AND RECREATION RIVERS				
Yellowstone River (22 miles of free-flowing stream)	Capital Cost $3,264,000 Annual Benefits $110,000 Annual Adverse Effects $263,400	Maintain scenic, recreation and wildlife options by preservation of 22 miles of free flowing stream from the North Dakota-Montana State line to the Missouri River.	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be regulated by purchase of 8 acres fee title and 4,480 acres of easement

Table VI-5 (Cont.). Display of Beneficial and Adverse Effects - EQ Plan, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Account: Environmental Quality	Account: Regional Development	Account: Social Well-Being
SCENIC AND RECREATION RIVERS (cont.)				
Knife River (76 miles of free-flowing stream)	Capital Cost $10,142,000 Annual Benefits $380,000 Annual Adverse Effects $964,300	Maintain scenic, recreation and wildlife options by preservation of 76 miles of free flowing stream from Manning, North Dakota to the Missouri River	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be regulated by purchase of 76 acres fee title and 16,720 acres of easement
Heart River (106 miles of free-flowing stream)	Capital Cost $16,796,000 Annual Benefits $530,000 Annual Adverse Effects $1,613,100	Maintain scenic recreation and wildlife options by preservation of 106 miles of free flowing stream from Heart Butte Dam to the Missouri River	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be regulated by purchase of 76 acres fee title and 23,320 acres of easement
Cannonball River (45 miles of free-flowing stream)	Capital Cost $7,274,000 Annual Benefits $225,000 Annual Adverse Effects $577,400	Maintain scenic, recreation and wildlife options by preservation of 45 miles of free flowing stream from the county road south of Shields, North Dakota to North Dakota Bridge 1806	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be regulated by purchase of 68 acres fee title and 9,900 acres of easement
Missouri River (86 miles of free-flowing stream)	Capital Cost $13,500,000 Annual Benefits $1,419,000 Annual Adverse Effects $1,251,300	Maintain scenic, recreation and wildlife options by preservation of 86 miles of free-flowing stream from Garrison Dam to the mouth of the Heart River at Fort Lincoln State Park	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be regulated by purchase of 16 acres fee title and 16,500 acres of easement

Table VI-5 (Cont.). Display of Beneficial and Adverse Effects - EQ Plan, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Account: Environmental Quality	Account: Regional Development	Account: Social Well-Being
PRIVATE IRRIGATION				
56,000 Acres of Existing Irrigation	Assumed at least equal to cost	Irrigation limited to existing 56,000 acres of development. Existing streamflow level would be maintained as well as existing stream water quality	Not Available	Present holders of water rights that have not developed their irrigation system would be restricted from such development
PRESERVATION				
Unique Woodland Areas	Capital Cost $120,240 Annual Benefits $0* Annual Adverse Effects *NED benefits could not be ascertained due to inadequate evaluation techniques.	Provides protection and management of 4,328 acres of ponderosa pine, 735 acres of limber pine, and 100 acres of columnar juniper by administrative action on federal lands and through acquisition of conservation easements on private land. Preserves the only known areas of such vegetation in North Dakota.	Annual Benefits $0* Annual Adverse Effects $8,250 *Regional dollar benefits could not be ascertained due to inadequate evaluation techniques	Acquisition of conservation easements by federa state or local agencies 3,231 acres of private land, thus preserving current tax base. Educational, cultural and recreational values would be maintained along with preservation of livestock and wildlife cover.
INSTREAM FLOW				
Modified Level of Streamflow (Table IV-11)	Not Available	Provide a level of flow not below the following provided natural conditions would permit. North Fork Grand River at Haley 8536 AF/year; Cannonball River at Breien, 68884 AF/Year; Little Missouri near Watford City, 186,326 AF/Year; Knife River at Hazen, 62,238 AF/year; Heart River near Mandan, 70,628 AF/year These flows would provide for conservation of fish and wildlife	Not Available	Would place restriction on water use for other purposes

Table VI-5 (Cont.). Display of Beneficial and Adverse Effects - EQ Plan, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Environmental Quality	Regional Development	Social Well-Being
BLM IMPOUNDMENTS				
BLM Impoundments (11 additional impoundments under ongoing program)	Assumed at least equal to cost	Provides better utilization of range	Not Available	Not Available
AGRICULTURAL PRODUCTION				
Agricultural production (future without level) North Dakota Tributaries	Assumed at least equal to cost	Not Available	Assumed to exceed cost	Not Available
LAND CONSERVATION				
Continue Ongoing Program	Assumed at least equal to cost	An additional 1,115,200 acres of land would be treated by 1985 increasing to 2,162,400 acres by the year 2000.	Assumed to exceed cost	Provide additional employment in the application and maintenance of proposed measures.

3. A demonstration that non-Federal financing can be expected.

Irrigation Projects

Several development projects were investigated in the North Dakota planning area. While none of these met the NED criteria they all met the State-regional development criteria, this with the exception that the State of North Dakota does not presently have a non-Federal financing plan for these developments.

Hazen-Stanton Unit--This unit is located at the confluence of the Knife and Missouri Rivers on the south bank of the Knife River between Hazen and Stanton, North Dakota. The plan of development calls for irrigation water being supplied from the Missouri River by a 253 cfs pumping plant with a total dynamic head of 54 feet. Four relift plants would also be required to serve the 12,650 irrigable acres of the unit. Relift plants would have capacities and lifts as follows: 211 cfs against a total dynamic head of 75 feet; 135 cfs, 115 feet; 36 cfs, 60 feet and 13 cfs, 60 feet. The delivery system arrangement would be somewhat complex because the service area is divided by a highway throughout much of its length.

Oliver-Sanger Unit--This unit is some 11 miles long and contains approximately 8,000 acres of irrigable land lying along the west bank of the Missouri River opposite the town of Washburn. The irrigable land occupies two benches, a recent river flood plain, and an old glacial stream terrace. Irrigation water would be furnished from the Missouri River by the main pumping plant, located near the upstream end of the unit, which would pump against a total dynamic head of 16 feet at a design capacity of 159 cfs. Six relift plants would be required to serve 8,000 irrigable acres. The delivery system arrangement would be complex and difficult because the area is divided its entire length by a railroad and paralleling highway. Lifts (TDH) and capacities

of the six relift plants are estimated as follows: 67 feet, 147 cfs; 50 feet, 15.6 cfs; 40 feet, 8.8 cfs, 60 feet, 19.2 cfs; 65 feet, 13 cfs; and 70 feet, 32.4 cfs.

Upper Portion of Painted Woods Unit--This unit originally consisted of approximately 3,500 acres of irrigable land in a rather compact body southeast of the town of Washburn. The land lies in a successively higher position above the Missouri River, beginning with the river flood plain and continuing to first and second benches of ancient glacial, river origin. Since the time of the original study, however, most of the land in the flood plain and first bench has been developed privately leaving only 610 undeveloped acres on the upper bench above Highway 83. Irrigation water for this unit would be furnished from the Missouri River by a pumping plant which would pump against a total dynamic head of 185 feet at a design capacity of 13 cfs. The water would be delivered to the high point of the unit at elevation 1,790 feet and distributed through a system of laterals.

Little Heart Unit--This unit includes approximately 3,100 acres of irrigable land forming a narrow 10-mile strip along the west bank of the Missouri River beginning about 5 miles south of Mandan. Most of this land lies on a terrace 40 to 75 feet above the river. Irrigation water would be delivered from the Missouri River by a pumping plant at the north end of the unit to pump against a total dynamic head of 86 feet at a design capacity of 62 cfs. A 12-mile canal would extend along the western edge of the area which would require a 19 cfs in-line relift plant with a total dynamic head of 50 feet to serve lands in the southern portion of the unit.

Fort Yates Unit--The unit contains approximately 4,260 acres of irrigable land in an 8-mile strip along the west shore of Lake Oahe adjacent to the town of Fort Yates. The land lies on a terrace 10 to 40 feet above the lake.

Irrigation water would be supplied from Lake Oahe by two pumping plants. The north plant would serve 3,350 irrigable acres and the south plant would supply 910 acres. The capacities and lifts of these plants are 67 cfs against a total dynamic head of 137 feet, and 18.2 cfs against a total dynamic head of 48 feet. Due to the fluctuation of the lake water level, the pumping plants must be designed to handle a wide range of pumping heads.

Broncho Reservoir--In the selected scheme for Broncho Dam and reservoir, the dam would be a rolled earthfill embankment with a maximum height of 124 feet above streambed at crest elevation, 1,990 and a length of 9,450 feet. The outlet works to the Knife River would have a capacity of 1,000 cfs. For gravity service to adjacent downstream lands, two canal outlet works would be provided with capacities of 15 and 45 cfs through the right and left abutments respectively. To accommodate the inflow design flood a morning glory-type spillway with maximum discharge of 19,430 cfs would be provided. Water surface area at the top of the conservation storage would be 3,400 acres and at the top of flood storage 4,650 acres. At maximum flood stage about 12,800 acres would be inundated for a short interval. A total of 10,000 acres of irrigable land could be served by the average annual yield of water.

Cannonball Division--The Cannonball Division composed of the Cannonball, Thunderhawk, and Mott units, includes three reservoirs and 21,000 irrigable acres in small parcels lying along the Cannonball River and Cedar Creek in southwestern North Dakota. Each unit of the Cannonball Division would include a storage dam and reservoir from which water would be released as required during the irrigation season and pumped from the stream to laterals serving the scattered parcels of irrigated lands. A drainage system, where it is required, would convey the excess water back to the stream channel for downstream use. Energy for pumping would be supplied from the Pick-Sloan Missouri Basin Program system over transmission facilities constructed for that purpose.

Cannonball Dam would be of rolled-earth construction with a crest length of 8,200 feet at elevation 2,284. There would also be three dikes with a combined length of 5,600 feet, with crest elevation 2,284. The glory-hole-type spillway, with crest elevation 2,227.6 would have a maximum capacity of 3,478 cubic-feet per second. The outlet works would have a capacity of 227 cubic feet per second at water surface elevation 2,187.

Reservoir storage would be allocated as follows:

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Inactive	2,172.0	350	2,000
Conservation	2,227.6	2,800	78,000
Flood Control	2,262.5	7,400	163,000
Super Storage	2,278.3	11,400	146,100
Total		21,950	389,100

Thunderhawk Dam would be of rolled-earth construction with a crest length of 10,970 feet at elevation 2,408.8. Its spillway would be of the ungrated drop-inlet-type with a crest elevation of 2,357.3 and a maximum capacity of 4,200 cubic feet per second. The outlet works would have a capacity of approximately 85 cubic-feet per second.

Reservoir storage would be allocated as follows:

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Inactive	2,325.0	600	4,600
Conservation	2,357.3	2,500	43,400
Flood Control	2,397.0	9,200	210,000
Total		12,300	258,000

Mott Dam would be of rolled-earth construction with a crest length of 14,650 feet, including dike section, at elevation 2,461.1. The spillway would be of the ungated drop-inlet-type, with crest elevation 2,422.5 and maximum capacity

4,200 cubic feet per second. The outlet works would discharge 100 cubic-feet per second with reservoir at elevation 2,391.5.

Reservoir storage would be allocated as follows:

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Inactive	2,391.5	400	3,300
Conservation	2,422.5	3,000	44,700
Flood Control	2,450.0	10,300	170,250
Total		13,700	218,250

The soils of these units are almost entirely alluvial. The principal soil series are Bank, Cheyenne, Havre, and Hall. Most of the arable land is permeable and sandy, and is underlaid by sand or gravel. Very little land has alkalinity or salinity problems.

The units are of two major topographic types: the dissected river flood plains which have been influenced by frequent flooding of the river, and the gently rolling adjacent terraces. Both areas will require some leveling.

Adequate drainage could be accomplished readily on these units. The irrigable areas are small and have very good relief over numerous nearby natural drainageways. Most of the soils have permeable sandy substrata. Project-type drainage requirements would probably be confined to the improvement of surface drainage on some upland areas, and installation of interceptor drains below terraces in a few localized areas.

Flood Control

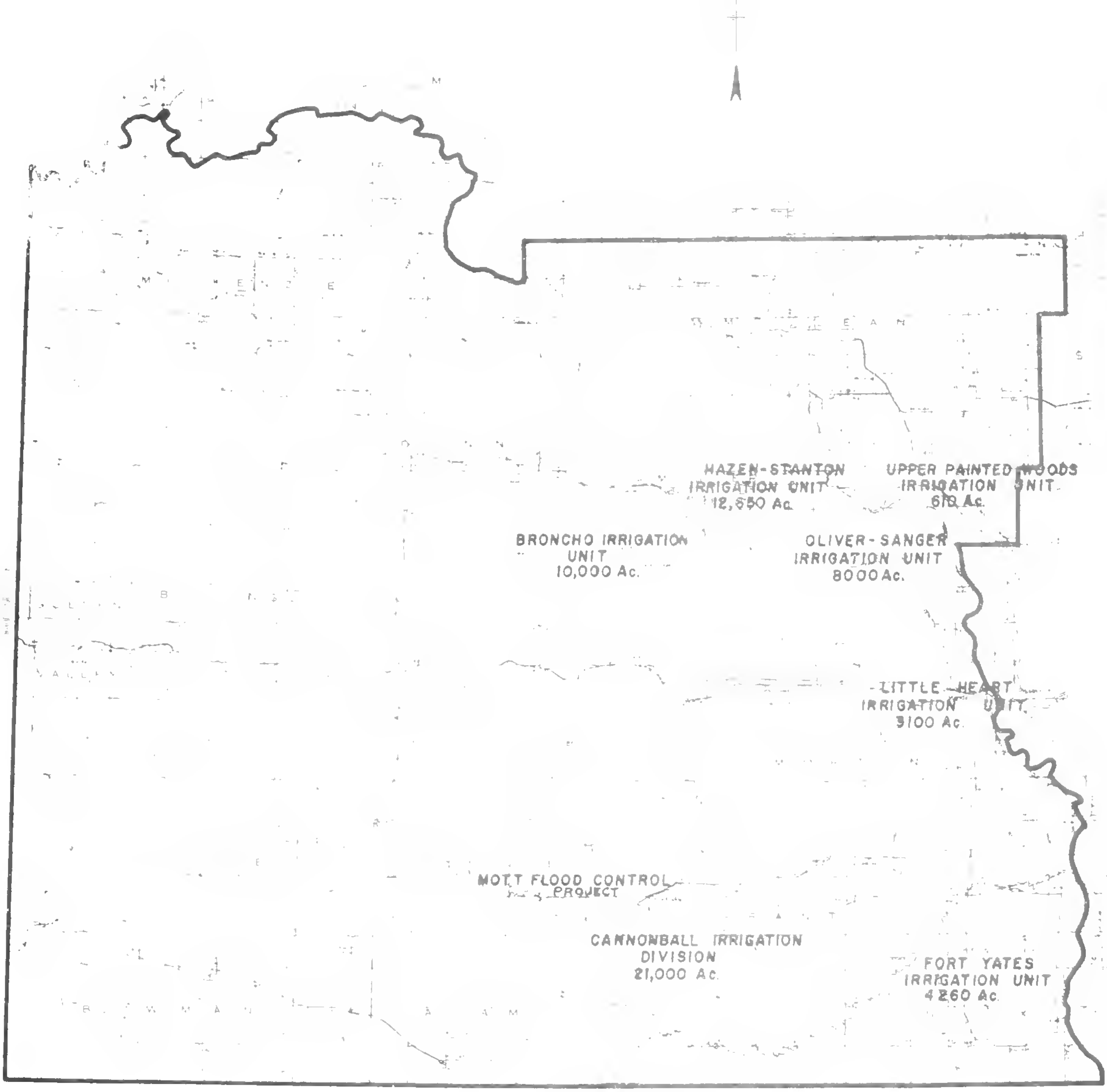
The Mott flood control project is for local protection of Mott, North Dakota. It would consist of a 2-mile levee and channel improvements along both banks of the Cannonball River. This project would protect 140 acres of urban land and improvements.

Beneficial and Adverse Effects of SRD Plan Elements

The beneficial and adverse effects of the SRD elements are shown in table VI-6. These brief descriptions of the effects were taken from the more detailed descriptions that were used during the plan formulation process. The general location of each SRD element is shown in figure VI-4.

Figure VI-4

STATE - REGIONAL DEVELOPMENT (SRD) NORTH DAKOTA TRIBUTARIES



YELLOWSTONE BASIN AND ADJACENT COAL AREA LEVEL B STUDY
MISSOURI RIVER BASIN COMMISSION

Table VI-6. Display of Beneficial and Adverse Effects - SRD Elements, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Environmental Quality	Regional Development	Social Well-Being
IRRIGATION				
Hazen-Stanton Unit (irrigation of 12,650 acres)	Capital Costs $24,806,000 Annual Benefits $1,192,900 Annual Adverse Effects $1,845,500	Additional habitat for small furbearing aquatic animals and upland game birds. Reduced wind erosion, increased productivity. Structures will impose visual intrusions on the area. Return flows will add 13,409 tons of total dissolved solids annually. This unit is estimated to take 51 miles of canals and 63 miles of drains for a total of 126 acres of water.	Annual Benefits $1,930,500 Annual Adverse Effects $1,845,500	Construction will bring 298 additional people into the area for a 3-year period. Unit will help local economy stabilize. The school enrollment is expected to increase by 33 for the construction period.
Oliver-Sanger Unit (irrigation of 8,000 acres)	Capital Costs $15,464,000 Annual Benefits $750,000 Annual Adverse Effects $1,181,200	Additional habitat for small furbearing aquatic animals and upland game birds. Reduced wind erosion, increased productivity. Structures will impose visual intrusions in the area. Return flows will add 8,438 tons of total dissolved solids annually. This unit estimated to take 44 miles of canals and 32 miles of drains for a total of 88 acres of water.	Annual Benefits $1,839,400 Annual Adverse Effects $1,181,200	Construction will bring 186 additional people into the area for a 3-year period. Unit will help local economy stabilize. The school enrollment is expected to increase by 21 for the construction period.
Upper Portion of Painted Woods Unit (irrigation of 610 acres)	Capital Costs $1,358,000 Annual Benefits $59,200 Annual Adverse Effects $97,500	Additional habitat for small furbearing aquatic animals and upland game birds. Reduced wind erosion, increased productivity. Structures will impose visual intrusions in the area. Return flows will add 647 tons of total dissolved solids annually. This unit is estimated to take two miles of drains and two miles of canals for a total of 5 acres of water.	Annual Benefits $149,400 Annual Adverse Effects $97,500	Construction will bring 25 additional people into the area for a 2-year period. Unit will help local economy stabilize. ject will help lo-

Table VI-6 (Cont.). Display of Beneficial and Adverse Effects - SRD Elements, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Account: Environmental Quality	Account: Regional Development	Account: Social Well-Being
IRRIGATION				
Little Heart Unit (irrigation of 3,100 acres)	Capital Costs $4,569,000 Annual Benefits $301,000 Annual Adverse Effects $344,800	Additional habitat for small furbearing aquatic animals and upland game birds. Reduced wind erosion, increased productivity. Structure will impose visual intrusions in the area. Return flows will add 3,286 tons of total disolved solids annually. This unit is estimated to take 16 miles of canals and 12 miles of drains for a total of 34 acres of water.	Annual Benefits $686,000 Annual Adverse Effects $344,800	Construction will bring 84 additional people into the area for a 3-year period. Unit will help local economy stabilize. The school enrollment is expected to increase by [illegible] for the construction period.
Fort Yates Unit (irrigation of 4,260 acres)	Capital Costs $6,365,000 Annual Benefits $412,600 Annual Adverse Effects $500,600	Additional habitat for small furbearing aquatic animals and upland game birds. Reduced wind erosion and increased productivity. Structure will impose visual intrusion in the area. Return flows will add 4,516 tons of total disolved solids annually. This unit is estimated to take 21 miles of canals and 17 miles of drains for a total of 45 acres of water.	Annual Benefits $945,400 Annual Adverse Effects $500,600	Construction will bring ___ additional people into the area for a 3-year period. Unit will help local economy stabilize. The school enrollment is expected to increase by ___ for the construction period.
Broncho Dam and Reservoir (irrigation of [illegible] acres)	Capital Costs $42,450,000 Annual Benefits $1,116,000 Annual Adverse Effects $3,912,000	A 3,400 acre reservoir would be created. Water oriented recreational activities would be available. Fishing in the Knife River below the dam would be slightly improved. Waterfowl resting habitat would be improved. Wind erosion would be reduced. Up to 4,650 acres of natural grassland, farmland, and wooded riparian habitat would be inundated by the reservoir. Structural features and exposed bankline during drawdown periods would be visual	Annual Benefits $3,398,000 Annual Adverse Effects $3,012,000	

Table VI-6 (Cont.). Display of Beneficial and Adverse Effects - SRD Elements, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Account: Environmental Quality	Account: Regional Development	Account: Social Well-Being
IRRIGATION Broncho Dam and Reservoir (cont.)		intrusions to the area. There would be some reduction in hunting opportunities. From 10 to 20 miles of free flowing stream habitat would be lost. Construction activities would create some temporary dust and aerial exhaust emissions.		
Cannonball Division Cannonball Unit (1,[illegible] acres of irrigation below Cannonball, Thunderhawk, and Mott Dams)	Capital Cost $25,111,000 Annual Benefits $1,100,000 Annual Adverse Effects $1,774,500	A reservoir of 3,150 acres would be created. This would provide for water-oriented recreation activities. Opportunities for pheasant hunting could improve. There would be a fair potential for establishing a reservoir fishery. At the flood storage level 21,950 acres would be inundated. Visual quality would be reduced from construction of the irrigation facilities. Several miles of free flowing streams would be impounded.	Annual Benefits $2,793,000 Annual Adverse Effects $1,774,000	Construction will bring 225 additional people into the area for a 4-year period. The school enrollment for the period is expected to increase by 77 children. The unit would help stabilize the local economy.
Cannonball Division Thunderhawk Unit (21,000 acres of irrigation below Cannonball, Thunderhawk, and Mott Dams)	Capital Cost $18,621,000 Annual Benefits $539,000 Annual Adverse Effects $1,293,000	A reservoir of 3,100 acres would be created. This would provide for water-oriented recreation activities. Opportunities for pheasant hunting could improve. There would be fair potential for establishing a reservoir fishery. At the flood storage level 12,300 acres would be inundated. Visual quality would be reduced from construction of the irrigation facilities. Several miles of free flowing streams would be impounded.	Annual Benefits $1,565,000 Annual Adverse Effects $1,293,000	Construction will bring 167 additional people into the area for a 4-year period. The school enrollment for this period is expected to increase by 57 children. The unit would help stabilize the local economy.

Table VI-6 (Cont.). Display of Beneficial and Adverse Effects - SRD Elements, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Account: Environmental Quality	Account: Regional Development	Account: Social Well-Being
IRRIGATION (CONT.)				
Cannonball Division, Mott Unit (21,000 acres of irrigation below Cannonball, Thunderhawk, and Mott Dams)	Capital Costs $29,305,000 Annual Benefits $638,000 Annual Adverse Effects $2,017,000	A reservoir of 3400 acres would be created. This would provide for water-oriented recreation activities. Opportunities for pheasant hunting could improve. There would be a fair potential for establishing a reservoir fishery. At the flood storage level 13,700 acres would be inundated. Visual quality would be reduced from construction of the irrigation facilities. Several miles of free flowing streams would be impounded.	Annual Benefits $2,134,000 Annual Adverse Effects $2,017,000	Project construction will bring 263 additional people into the area for a 4-year period. The school enrollment for this period is expected to increase by 89 children. The unit would help stabilize the local economy.
FLOOD CONTROL				
Mott Local Protection Project (2.0 miles of levees and 0.6 mile of channel improvement on Cannonball River)	Capital Cost $2,215,000 Annual Benefits $112,000 Annual Adverse Effects $153,000	3 acres of clearing and grubbing would reduce wildlife habitat. Improved weed reduction, better drainage, and mosquito control.	Annual Benefits $179,000 Annual Adverse Effects $153,000	Protect 140 acres of urban land and improvements from flooding, enhancing the health and social well being of 1300 residents.

CHAPTER VII

THE RECOMMENDED PLAN

Selected Plan Elements

In the selection of plan elements to be included in the recommended plan the basis for justification included two primary considerations: (1) satisfaction of the remaining needs identified in chapter IV, and (2) was the plan element a part of the future without plan discussed in chapter V, or an element of the NED and EQ alternative plans or SRD analysis discussed in chapter VI.

Also, in order for an element to be included in the recommended plan the means of implementing that element had to be available or a recommendation made that would lead to its being implemented. For a more detailed description and analysis of the plan elements included in the recommended plan the reader is referred to appendix 6a.

The results of this Level B study must be interpreted in perspective. Even though the recommended plan contains several environmentally oriented elements, the various account displays for these elements are not as strong as one may wish. Reasons for that weakness are discussed in the recommendations section, but briefly they relate to the fact that many of the elements included had not been examined prior to this study.

In addition, the environmental account displays other planning elements that often are incomplete due to the lack of environmental base data and lack of participation and knowledgeable inputs by some of the environmentally based State and Federal agencies. As a consequence, environmental elements and account displays must be given the benefit of the doubt when examined for completeness and accuracy.

Knife River Indian Villages National Historic Site Erosion Control

The Knife River Indian Villages National Historic Site is administered by the National Park Service. Nearby, the town of Stanton is located about 50

miles northwest of Bismarck, North Dakota, near the confluence of the Knife River and the Missouri River. The Knife River Indian Villages National Historic Site is located immediately north of Stanton and covers an area of about 1,200 acres. Streambank erosion occurs along the Knife River at the Sakakawea Site. The recommended project involves construction of a berm and rock protection along an 1,800-foot reach of river bank adjacent to the Sakakawea Site. This project would help protect an area of archeological and historic significance.

Hazen Flood Control

This project is a joint effort of local, State and Federal governments to protect the City of Hazen, North Dakota from damages that occur as a result of flooding from Antelope Creek. While this project is in the early planning stages, with actual structural features and costs subject to change, it was adopted for inclusion in the recommended plan.

BLM Impoundments

The BLM has 31 impoundments in the area and 11 more are predicted to be constructed by the year 2000 under an ongoing program. These were adopted from the future without plan discussed in chapter V.

Non-Energy Minerals

Sand and gravel has dominated nonenergy mineral production in the North Dakota area, although in terms of water requirements the processing of nonbentonic clay for brick production has been the highest consumptive user of water. Non-energy industry water needs from the future without plan were adopted for the recommended plan. The required water supply is expected to follow past trends of private development.

Scenic and Recreation Rivers

Yellowstone River - North Dakota - Montana State line to Missouri River. This river reach totaling approximately 22 miles was included in the recommended plan as an addition to a State Recreation River System. The plan includes acquisition of 8 acres in fee title and 4,480 acres of easement.

Knife River - Manning, North Dakota, to Missouri River. This river reach, totaling approximately 76 miles was included in the recommended plan as an addition to a State Recreation River System. This plan includes acquisition of 76 acres in fee title and 16,720 acres of easement.

Heart River - Heart Butte Dam to Missouri River. This river reach, totaling approximately 106 miles, was included in the recommended plan as an addition to a State Recreation River System. The plan includes acquisition of 76 acres in fee title and 23,320 acres of easement.

Cannonball River - County road south of Shields to North Dakota Bridge 1806. This river reach, totaling approximately 45 miles, was included in the recommended plan as an addition to a State Recreation River System. The plan includes acquisition of 68 acres in fee title and 8,900 acres of easement.

Missouri River - 11 miles downstream from Garrison Dam to Fort Lincoln State Park. This river reach, totaling approximately 75 miles, was included in the recommended plan as an addition to the National Wild and Scenic Rivers System. The plan includes acquisition of 16 acres in fee title and 16,500 acres of easement. This proposal reduces by 11 miles the potential recreation river use of the Missouri to accommodate the installation of additional hydropower units at Garrison Dam and the associated reregulation reservoir to be located approximately 11 miles downstream from Garrison.

Agricultural Production

Agricultural projections were made by an ad hoc group of State and Federal representatives. For complete details the reader is referred to their report, Agricultural Projections and Supporting Data, November 1976. The following levels of production, based on their projections included in the future without plan, were adopted for the recommended plan.

Crop	Unit	Base1/	1985	2000
Wheat	Bu.	40,584,000	44,935,000	47,438,000
Rye	Bu.	531,000	605,000	636,000
Corn for Grain	Bu.	128,000	204,000	252,000
Silage	Tons	539,000	566,000	773,000
Oats	Bu.	19,445,000	23,174,000	24,092,000
Barley	Bu.	10,157,000	12,672,000	13,342,000
Hay	Tons	1,406,000	1,373,000	1,482,000
Soybeans	Bu.	10,0002/	---	---
Flaxseed	Bu.	526,000	625,000	702,000
Sugar Beets	Tons	114,000	206,000	352,000
Irish Potatoes	Cwt.	183,0002/	371,000	409,000
Dry Beans	Cwt.	25,0002/	21,000	41,000

1/ Base in 1972 - 1974 average unless noted otherwise.

2/ 1969 Agricultural Census.

Livestock	Unit	Base3/	1985	2000
Beef and Veal	Lbs.	381,849,000	438,187,000	480,653,000
Pork	Lbs.	26,118,000	22,638,000	19,800,000
Lamb and Mutton	Lbs.	5,232,000	4,461,000	3,597,000
Chickens	Lbs.	672,000	428,000	286,000
Turkeys	Lbs.	360,4004/	414,000	333,000
Eggs	Doz.	2,449,000	1,928,000	1,384,000
Milk	Lbs.	190,336,0005/	152,777,000	126,485,000

3/ Base is 1974 unless noted otherwise.

4/ 1969 percent of State production times 1974 State production.

5/ Estimate is from North Dakota State Department of Agriculture for Commercial Market, from July 1, 1972 to June 20, 1973.

The acres required to meet these projections, using future without projected yields, are 4,007,803 acres of nonirrigated lands and 102,155 acres of irrigated lands by 1985; and 4,514,691 acres of nonirrigated land and 177,562 acres of irrigated land for the year 2000. To meet the feed units required for roughage under the Series E' projection for livestock would require an additional 235,435 acres of irrigated land in the year 2000.

Private Irrigation

Existing irrigation development within the North Dakota planning area totals approximately 56,000 acres. Private irrigation development has been projected, under the future without plan, to increase this total to 86,000 acres by 1985 and 135,000 acres by the year 2000. Of this total 66,500 acres by the year 1985 and 92,000 acres by the year 2000 are projected to utilize surface waters, primarily in the form of water spreading. The remaining acreages - 19,500 acres by the year 1985 and 43,000 by the year 2000 - are projected to utilize ground water sources. This projected private irrigation development was adopted for inclusion in the recommended plan.

Energy Development

Development of coal resources included in the North Dakota portion of the planning area and adopted in the recommended plan included the following existing or proposed developments. Existing thermal electric generating plants included a 172-MW UPA plant at Stanton, 652-MW BEPC plant at Stanton, 234-MW MPC plant at Center, 101-MW MDU plant at Mandan, and a 14.9-MW MDU plant at Beulah; plants presently under construction include a 440-MW MPL plant at Center and a 900-MW UPA-CPA plant at Falkirk. Proposed thermal electric plants for which water permits have been approved include a 880-MW BEPC plant at Beulah and a 440-MW joint venture plant at Beulah. Also a 250-mcfd coal gasification plant proposed by American Natural Gas, for which a State water permit has been granted, is included in the recommended plan. Since coal gasification is not economical at current prices it would require subsidization to be built. A part of the recommended plan is that the coal gasification plant be built by 2000 providing price relationships are such that no subsidy is needed. Water delivery systems as permitted for these developments will be provided by private enterprise, with resource requirements as shown in table VII-1.

Table VII-1 . Recommended Plan Energy Development Scenario
Estimated Resource Requirements and
Air Pollutant Emissions 1/
North Dakota Tributaries

Item		1985	2000
Coal Production 2/	Million Ton/Year	24	36
Study Area Generation	" " "	21.5 3/	21.5 3/
Syngas	" " "	0	12
Export	" " "	2.5	2.5
Thermal Electric Plants 2/	Total Number	9	9
Megawatt Capacity	Megawatts	3834	3834
Gigawatt-hour/year	Gigawatt-hour/year	23510	23510
Coal Gasification Plants	Total Number	0	1
Production	MCFD	0	250
Water Requirements			
Mines	Acre-feet/year	480	720
Reclamation	" " "	3576	5364
Coal Gasification	" " "	0	10000
Electric Generation	" " "	58660	58660
Slurry Pipeline	" " "	0	0
Total	" " "	62716	74744
Labor Requirements			
Mines	Man-years/year	576	864
Coal Gasification	" " "	0	625 4/
Electric Generation	" " "	498 4/	498 4/
Total	" " "	1074	1987
Capital Requirements			
Mines	Million Dollars	108 5/	208 5/
Coal Gasification	" "	0	1000
Electric Generation	" "	433 6/	433 6/
Total	" "	541	1641
Land Requirements			
Strip Mining Area	Acres/year	919	1379
Sites			
Mines	Acres	720	1080
Coal Gasification	"	0	400
Electric Generation	"	3834	3834
Total	"	4554	5314
Air Pollutant Emissions			
Particulates	Tons/year	11775	12872
Sulfur Dioxides	" "	141060	153324
Nitrogen Oxides	" "	117550	279065

1/ Source unless otherwise noted, Analysis of Energy Projections and Implications for Resource Requirements, Harza Engineering, Dec. 1976.

2/ Source North Dakota Public Service Commission, Jan. 1977.

3/ A portion of the coal needs supplied by burning fines resulting from preparation of lignite for associated coal gasification plant.

4/ Operating personnel only.

5/ Excludes 1975 level.

6/ Excludes requirements for plants existing or under construction (1977).

Several suggestions are made regarding coal development. It was suggested that slurry of North Dakota coal be controlled by adoption of legislation similar to that of Montana. Montana law does not recognize water use for coal slurry as a beneficial use. Higher levels of funding for land reclamation research is suggested. Additional studies were also suggested on the effects of coal development on air quality and ground and surface water and its social impacts; on the amounts of acreage disturbed; on the availability of other (non-North Dakota) coal resources; and on other forms of energy development such as solar and wind.

National Economic Development Account - Table VII-2 is the National Economic Development account for the recommended energy plan.

Regional Account - For the base period level of electricity production it was assumed that 60 percent of total generation would be exported from the State, leaving 40 percent to be used in North Dakota. Based on relative population, it was assumed that one-sixth of the remaining 40 percent would be a direct benefit to the area.

The Underwood 1 and 2 thermal electric units were assumed to be all export. These units are projected to come on line in 1978 and 1979, respectively. Electricity from the remaining plants (1,320 megawatts of capacity) was assumed to be used totally within North Dakota. Of the 1,320 megawatts, it was assumed that 880 megawatts would be needed in the planning area for coal gas and other mining uses. It was assumed that all the coal gas would be exported. The direct costs for the energy-related facilities were distributed to the three regions--region, adjacent regions, and rest of Nation--in the same manner.

Table VII-2. NED Account for Recommended Energy Plan
North Dakota Tributaries 1/

	(Millions of $)
Yearly Benefits	
Electricity	212.2
Export Coal	19.2
Coal Gasification 2/	80.4
Total Gross Benefits	311.8
Yearly Costs	
Electricity	180.4
Export Coal	16.3
Coal Gasification	80.4
Loss of Agricultural Production 3/	.21
Total Costs	$277.31
Net Benefits Per Year	$ 34.49

1/ Based on data provided by Don Ohnstad, Ass't Study Manager, May 20, 1977, and data in Analysis of Energy Projections and Implications for Resource Requirements by Harza Engineering Company, December 1976.

2/ One 250 MCFD plant assumed to be in production as of 1990, with benefits equal to costs.

3/ Estimate based on Durum wheat following fallow which nets $26 per cropped acre to the land, overhead, risk and management. Since it requires one acre of idle land for fallow for each cropped acre, the effective return is $38 per acre.

All direct costs and benefits were scheduled according to construction periods and on-line dates provided by study management. The following schedule was adhered to:

Plants	Megawatts of Capacity	On-line
Existing	1,614 MW	Now
Underwood 1	450	1978
Underwood 2	450	1979
Antelope Valley 1	440	1981
Coyote	440	1981
Antelope Valley 2	440	1984
Coal gasification	250 MCFD	1990

The appropriate benefits and costs were discounted at 6 3/8 percent for 30 years for each region and then amortized to get an annual value.

Estimates of local and State taxes generated by the mines, plants, and mine and plant workers were provided from ERS's computer model ENGYTX.[30/] The following assumptions were used for estimating taxes from the mines and plants.[31/]

1. Taxes do not reflect sales or use tax on initial facilities and equipment.
2. No extraordinary equipment purchases occur during the year.
3. Property tax rates used were for Mercer County and the average levy for Beulah, Hazen, Stanton, and Zap school districts.
4. The model assumed that all new employees of the mine or plant locate in the school district and county in which the mine is located.
5. The mines and plants were assumed to be outside the limits of any town.
6. Estimates were made only for taxes paid by the mine or plants and the mine or plant employees and their immediate families.
7. The mines were assumed to be operated by a corporation conducted business solely within the State. To the extent that business is conducted out of State, corporate income tax revenues will decrease.

30/ A computer simulation model developed by the Economic Development Division of ERS and under the direction of Thomas F. Stinson, ERS, who is located at the University of Minnesota, St. Paul.

31/ Memorandums from Thomas F. Stinson, Economist, Economic Development Division, ERS, dated May 24, 1977, and June 2, 1977.

8. The housing choice patterns of workers and family characteristics of the workers were assumed to be the same as those developed in Profile of North Dakota's Coal Mine and Electric Power Work Force, NDSU, Ag. Exp. Station, Ag. Econ. Report No. 100, by Arland Leholm, F. Larry Leistritz and James Wieland.

9. The estimates reflect the tax systems as of July 1976.

10. No corporate income tax was estimated for the electric or gas plants.

11. No estimates were made of sales taxes or property taxes on the structure housing the gas plant.

Once the taxes were estimated for each year and each level of government, they were discounted to 1976 and then amortized to obtain an average annual value.

Under the above assumptions it appears that local and State tax estimates are conservative. However, one does get an idea of the magnitudes and relative levels of taxes. The important thing to note is that the State would receive considerable tax income from the energy related developments. In addition, most of the State's taxes can be shifted to those who buy the energy. To the extent that the tax levels truly reflect real impacts on the State and local areas, such a shift seems reasonable. However, to the extent that the taxes exceed costs (direct as well as external) to the State and local areas, the passing of taxes to consumers of electricity is probably not equitable. A summary of the regional account for the energy level in the recommended plan is shown by table VII-3.

Environmental Quality Account - Beneficial Effects - Energy development will have no significant beneficial effects on the nonhuman environmental quality of the area.

Adverse Effects - Areas of natural beauty and human enjoyment: energy-related facilities impose definite long-term obtrusions to the visual quality in

Table VII-3. Regional Account for Energy Level in Recommended Plan North Dakota Tributaries

	Region	Adjacent Region	Rest of Nation	Nation
	(Millions of $)			
Beneficial Effects				
Direct User Benefits				
Electricity	47.3	51.1	113.8	212.2
Export Coal	-	-	19.2	19.2
Coal Gas	-	-	80.4	80.4
Total	47.3	51.1	213.4	311.8
Direct Regional Taxes on Mines and Plants				
Taxes Received 1/	3.7	21.1	0	
Taxes Paid 2/	3.7	4.1	17	
Net Taxes	0	17.0	-17.0	0
Secondary Benefits	NA 3/	NA	NA	0
Costs				
Direct Costs				
Electricity	40.2	43.5	96.7	180.4
Export Coal	-	-	16.3	16.3
Coal Gasification	-	-	80.4	80.4
Loss of Ag. Production	0.21	-	-	.21
Total	40.41	43.5	193.4	277.31
Secondary Costs	NA	NA	NA	0
Net Benefits	6.89	7.6	20.0	34.49

1/ Taxes received from mine and plant facilities. Some of the tax to the region goes to the State first and is then redistributed.

2/ Based on proportion of benefits received.

3/ Not estimated due to lack of adequate data.

their vicinity. Such facilities include the coal mines, coal-fired generating plants, electric transmission lines, and water supply. The anticipated number of major facilities in 1985 and 2000 is as follows:

State	Coal Mines		Electric Plants		Gasification Plants	
	1985	2000	1985	2000	1985	2000
North Dakota	9	10	9	9	0	1

Land requirements for these facility sites range from 4,554 acres in 1985 to 5,314 acres in the year 2000. In addition, strip mining activities will affect 919 acres in 1985 and 1,379 acres in 2000. The use of lands for this purpose will preclude their use for recreational and other human activities for a long period of time. Energy development already has resulted in expansion of urban centers within the area and especially those towns and cities closest to the major energy facility sites.

Increased rail and highway traffic is an annoyance in the area. Noise created by mining, transportation, and energy conversion of the coal resources is disturbing to nearby rural inhabitants and population centers.

Aerial emissions from energy production are esthetically displeasing, not only at the immediate sites of major facilities, but because smokestack emissions have a significant effect for long distances downwind from sites of energy conversion plants.

Biological, geological, and ecological elements: Vegetation removal from sites of major energy production facilities will amount to from 4,554 acres (1985) to 5,314 acres (2000) of natural grassland and cultivated cropland. These areas remain unvegetated for the life of the facilities. Strip mining activities destroy additional vegetative communities at the rate of about 919 acres/year in 1985 and 1,379 acres/year in 2000. Reclamation of these lands takes from 3 to 5 years under normal climatic conditions. Under a continuous reclamation program, the number of acres of lands being reclaimed at any one time will amount

to three to five times the amount of those lands being strip mined during any 1-year period. However, the potential for fully reclaiming some of the strip mined lands to natural vegetation or to cropland is still unproven.

Natural vegetation and crops on the land surrounding, and downwind from, energy conversion plants are and will be subjected to low levels of aerial contaminants over a long period of time. Such exposure may cause acute or chronic injury to such vegetation, and may also inhibit growth.

Lands used for major energy facility sites are lost as wildlife habitat for the life of the facilities. Strip mined lands are also lost as wildlife habitat until they are reclaimed. The habitat value of the reclaimed lands will be dependent on the level of success of the reclamation program. Wildlife populations most likely reduced by habitat losses and habitat deterioration or fragmentation include pronghorn antelope, deer, native grouse, coyotes, and small grassland birds, mammals, and reptiles. Also, as long as the affected lands are in an unvegetated or sparsely vegetated condition, they will be unavailable to domestic livestock for grazing.

Depletions of water supplies and potential degradation of water quality, caused by energy production, have and will have, harmful effects on aquatic life in the streams and impoundments from which the supplies are drawn.

Strip mining disturbs the natural topography of the landscape. Natural surface drainages as well as ground water levels and flows are altered at least temporarily. Disturbance of soils results in changes in soil permeability and exposes earth surfaces which contain high concentrations of salts, nutrients, and trace elements. Although topsoils may be removed during the mining process for later replacement, the remaining soil strata may be so disturbed that the resultant soil configuration may not produce vegetation of equal quantity or quality.

Irreversible considerations: Mining activities within the area produce millions of tons of coal per year. Utilization of this resource for energy production within and outside of the area is a permanent irreversible use of a nonrenewable resource. Water requirements for mining and for energy conversion amount to thousands of acre-feet per year. This is an irreversible use of some water resources on a yearly basis. Total projected coal production and water requirements for the area are as follows:

Coal Production - North Dakota Tributaries
(million tons/year)

1985	2000
24	36

Water Requirements - North Dakota Tributaries
(acre-feet/year)

1985	2000
62,716	74,744

Significant disturbance or destruction of archeological or historical sites, especially of unidentified sites, may occur. This adverse effect is often irreversible depending on the location and nature of the affected site.

Water quality: The quality of both surface and ground water in the area and adjacent areas most likely suffers some degradation. Strip mining activities result in increased runoff and erosion from land surfaces, with increased siltation of surface waters. Leaching of exposed earth surfaces, such as spoil piles and coal stockpiles, can result in increased mineralization of surface and ground waters. Potential dewatering of mine and plant excavations into natural waterways adds to the TDS concentration of receiving waters. Withdrawal of water for energy development activities, and not returning some, also tends to increase the TDS concentrations in the respective streams, water impoundments, and ground water aquifers.

Aerial emissions from energy conversion plants have a degrading effect on surface and ground waters. Salts from cooling tower drift and fly ash, sulfur and nitrogen oxides, and trace elements eventually precipitate out of the atmosphere and fall on soil or water surfaces. Contaminants which are deposited on soil surfaces may be rewetted by precipitation and then enter ground or surface waters. The end result is increased mineral, acid, and nutrient concentrations in these waters.

Air quality: Strip mining activities, such as excavating, blasting, loading, and hauling, create significant levels of dust and exhaust emissions at the mining sites and along coal transportation corridors. Wind erosion of disturbed land surfaces, as well as potential coal refuse fires, create air pollution problems in the mining areas.

Stack emissions from energy conversion plants have an effect on air quality of the area. People living around and downwind from energy conversion plants are and will be subjected to low levels of several contaminants over a long period of time. Such exposure may cause acute or chronic respiratory problems and may also result in other, as yet, unidentified health injury. The major aerial pollutants emitted by the coal-fired generating plants and coal gasification plants are fly ash, sulfur and nitrogent oxides, and trace elements. The predicted levels of air pollutant emissions are as follows:

Emissions (Tons/Year)	North Dakota Tributaries	
	1985	2000
Particulates	11,775	12,872
Sulfur Oxides	141,060	153,324
Nitrogen Oxides	117,550	279,065
Total	270,385	445,261

The impacts of these aerial emissions may extend beyond the area. With the level of impact decreasing proportionate to the increase in distance from the

emission sites. Expansion of urban centers as a result of energy development also contributes to the degradation of air quality in the study area.

Social Well-Being Account - Beneficial Effects - Approximately 1,470 new jobs in the energy industry would be created directly by 1985 and 2,055 positions by 2000. In addition, indirect employment of 1,790 and 2,630 will be provided by 1985 and 2000 respectively. New jobs will provide a means for reducing the out-migration of young people. Stabilizing the employment picture will help to stabilize the local economy.

Many of the jobs in the energy industry are higher paying that the average income in the area (information from backup material provided by Harza Engineering Company). Income distribution would change as shown in table VII-4.

The mean real family income could be expected to rise about $335 by 1985 and $685 by 2000.

Adverse Effects - The arrival of additional people necessary for construction and operation of mines and plants could alter existing social characteristics of smaller communities. Information from public involvement during the study indicates that such effects would be considered negative. In addition, publicly provided services are likely to be overextended, particularly in the short run.

While the percentage of all families in the upper income brackets increases, many of these are likely to be immigrants. The population that would exist without the energy development is more likely to be receiving the lower levels of income, even with energy development.

Instream Flows

The level of instream flows shown in table VII-5 was selected for inclusion in the recommended plan, provided the streamflows are available. Because instream flow is not recognized as a benenficial use in North Dakota at the present time, modification of the State water law would be required to effect this.

Table VII-4. Income Distribution Effects of Recommended Energy Plan
North Dakota Tributaries

Income Class	Current1/	19852/	20002/
	Percent of Families by Income Class		
Less than 2,000	8.5	8.0	7.9
2,000 to 3,999	15.5	14.7	14.5
4,000 to 5,999	17.1	16.2	16.0
6,000 to 7,999	16.5	15.6	15.4
8,000 to 9,999	13.7	13.0	12.8
10,000 to 14,999	19.3	18.9	18.0
15,000 to 24,999	7.8	12.0	13.8
25,000 and above	1.6	1.6	1.6

1/ From "Current and Projected Population, Income and Earnings" report of Ad Hoc Work Group on Projections, Yellowstone River Basin and Adjacent Coal Area Level B Study.

2/ Based on the following assumptions: (1) each worker represents a family; (2) salary levels are such that all coal mine workers and conversion plant workers earn from $15,000-24,999 except for two percent who earn over $25,000; (3) 50 percent of the construction workers earn $10,000-14,999 and 50 percent earn $15,000-24,999; (4) the indirect employment income is distributed the same as the income in the current period; and (5) all income ranges are held at 1975 real levels.

Table VII-5. Instream Water (cfs) for Selected Rivers in the Recommended Plan North Dakota Tributaries

Stream and Location	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
North Fork Grand River												
At Haley , N.D.	1	2	45	29	19	35	4	1	1	1	1	1
Cannonball River												
At Regent, N.D.	1	5	45	20	20	44	14	6	4	1	3	3
Below Bently, N.D.	4	15	121	45	47	78	24	11	9	7	9	6
At Breien, N.D.	6	39	313	233	129	236	90	25	15	16	18	11
Cedar Creek near Haynes, N.D. (Tributary)	2	4	33	26	24	51	14	8	2	2	3	2
Cedar Creek near Pretty Rock, N.D. (Tributary)	2	14	91	72	28	61	22	7	3	2	3	3
Cedar Creek near Raleigh, N.D. (Tributary)	1	8	95	62	114	96	34	7	9	2	2	3
Little Missouri River												
At Marmarth, N.D.	4	160	445	250	196	360	137	47	25	33	20	7
At Medora, N.D.	2	75	528	370	300	400	180	64	30	29	18	7
Near Watford City, N.D.	1	187	939	470	299	583	270	122	59	68	28	8
Knife River												
At Manning, N.D.	1	6	44	55	19	28	21	3	6	2	2	2
Near Golden Valley, N.D.	6	27	190	138	54	83	31	14	7	7	9	6

Table VII-5. Instream Water (cfs) for Selected Rivers in the (cont.)
Recommended Plan
North Dakota Tributaries

Stream and Location	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Knife River												
At Hazen, N.D.	16	51	316	222	53	167	73	28	25	26	27	19
Spring Creek near Zap, N.D. (Tributary)	3	13	69	63	22	28	14	5	7	7	7	5
Heart River												
Near South Heart, N.D.	1	8	56	25	20	27	5	6	1	1	1	1
Below Dickinson Dam, near Dickinson, N.D.	1	1	35	30	14	31	12	6	2	1	1	1
Near Richardton, N.D.	3	15	180	97	53	78	42	9	8	6	7	6
Below Heart Butte Dam Near Glen Ullin, N.D.	23	16	62	157	50	62	67	55	54	47	34	26
Near Lark, N.D.	19	23	230	186	57	139	81	67	32	49	39	28
Near Mandan, N.D.	13	23	283	243	71	165	96	77	65	55	42	25
Green River near New Hradec, N.D. (Tributary)	1	1	42	43	12	11	12	1	1	1	1	1
Green River near Gladstone, N.D. (Tributary)	1	7	73	58	13	25	21	4	3	3	4	3

Unique Woodland Areas

This proposal provides for the protection and management of 4,328 acres of ponderosa pine, 735 acres of limber pine, and 100 acres of columnar juniper and adjacent areas by administrative action of Federal lands and through acquisition of easements on private lands. The 735 acres of limber pine are located in western Slope County of which 532 acres are in Federal ownership and 203 acres are privately owned. No other native stands are found in North Dakota or eastern Montana. About 4,328 acres of ponderosa pine are found along the Little Missouri River, of which 1,932 acres are Federally owned and 3,028 acres are privately owned. This is the only native ponderosa pine in North Dakota. A small stand of columnar juniper is located in the proximity of the Burning Coal vein northwest of Amidon, North Dakota, occupying 100 acres in Federal ownership. The plan calls for easement acquisition of 3,231 acres of private land.

Streambank Protection

Missouri River and Yellowstone River - Streambank erosion protection along the Missouri River between Garrison Dam and Lake Oahe was included in the recommended plan. This ongoing project (streambank erosion control evaluation and the Demonstration Act of 1974 plus amendments) involves the installation of selective river management techniques using variations of several different types of structural bank protection measures at 21 key locations along the Missouri River and at 24 key locations along the lower Yellowstone River between Intake, montana and the mouth of the river in North Dakota. (For additional information on Yellowstone River bank stabilization see the Montana Study Team report).

Hydroelectric Power

The tentative proposal is to construct additional hydroelectric power units at Garrison Dam. The three new units would have an installed capacity of 272 megawatts and would cost about $70 million, not including the reregulating structure. A westward extension of the existing powerhouse would utilize three

modified flood control tunnels for penstocks, thereby permitting a large saving in construction costs. The plan selected would include a reregulation dam about 11 miles downstream of Garrison Dam, upstream of the confluence with the Knife River.

Display of the Plan

The elements selected by the Study Team for inclusion in the recommended plan are shown in figure VII-1. A summary of the four-account analysis of each of these elements is shown in table VII-6. In addition the recommendations as listed in chapter X are a part of the recommended plan.

Figure VII-1

RECOMMENDED PLAN
NORTH DAKOTA TRIBUTARIES

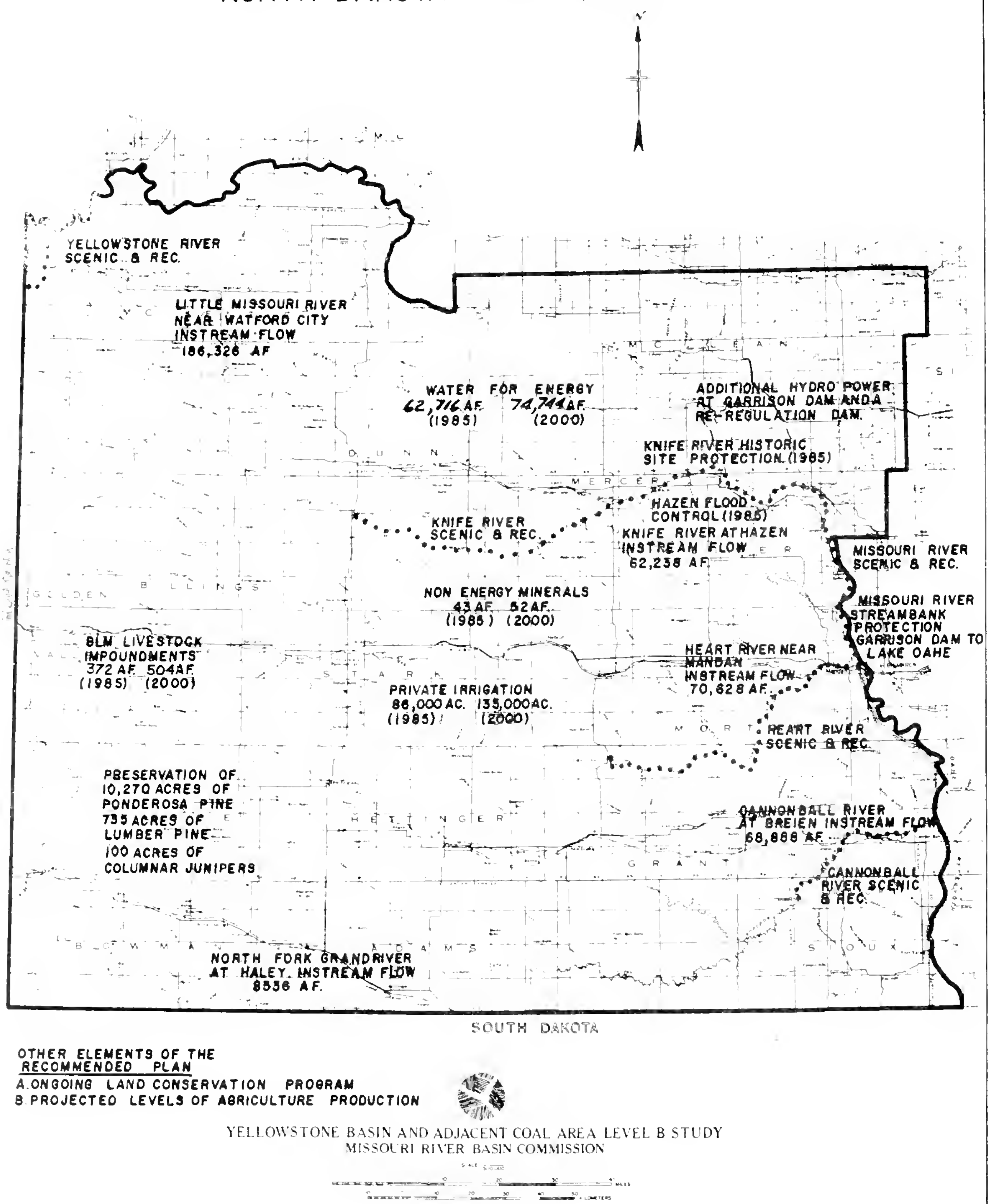


Table III-[illegible]. Display of Beneficial and Adverse Effects - Recommended Plan, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Environmental Quality	Regional Development	Social Well-Being
STREAMBANK EROSION				
White River Historical Site Protection (berm and rock protection along an 1,800-foot reach)	Capital Cost [illegible],000 Annual Benefits 0 Annual Adverse Effects [illegible]	Preservation of an irreplaceable archeological resource and restore the natural setting of the period of historic importance	Annual Benefit [illegible] Annual Adverse Effects	Minor amount of increases in local employment during project construction
FLOOD CONTROL				
Hazen Flood Control (Provides Hazen protection from flooding of Antelope Creek)	Capital Costs Not Available Annual Benefits [illegible],000 Annual Adverse Effects $17,100	Air pollution increased slightly during project construction. Channel relocation will cause a temporary increase in downstream bank erosion	Annual Benefit [illegible],44[illegible] Annual Adverse Effects $7,[illegible]	Create [illegible] skilled jobs for 90 days and [illegible] man-days of part time employment [illegible] local residents each year. Provide an estimated 9[illegible] reduction of flood damages to the flood plain
BLM IMPOUNDMENTS				
BLM Impoundments (11 additional impoundments under ongoing program)	Assumed at least equal to cost	Provides better utilization of range.	Not Available	Not Available
NON ENERGY MINERALS				
Non Energy Minerals (Sand, gravel, clay, others)	Assumed at least equal to cost	Not Available	Not Available	Not Available

Table VII-6. (Cont.). Display of Beneficial and Adverse Effects - Recommended Plan, North Dakota Tributaries

Plan Function/Element	Account			
	National Economic Development	Environmental Quality	Regional Development	Social Well-Being
AGRICULTURAL PRODUCTION				
Agricultural Production (Future Without Level)	Assumed at least equal to cost	Not Available	Assumed to exceed cost	Not Available
PRIVATE IRRIGATION				
86,000 acres by 1985 135,000 acres by 2000	Assumed at least equal to cost	Irrigation development could provide better interspersion of food and cover for wildlife. Streamflows would be somewhat depleted and water quality decreased. Irrigation is projected to reach 86,000 acres by 1985 and 135,000 acres by the year 2000.	Assumed to exceed cost	Irrigation would help stabilize rural population
ENERGY DEVELOPMENT				
Recommended Energy Development Scenario (Table VII-1 coal production of 24 million tons/year by 1985 and 36 million tons/year by 2000)	Capital Cost $1,641,000,000 Annual Benefits $311,800,000 Annual Adverse Fffects $277,310,000	Energy related facilities impose long term obtrusions to the visual quality of the area. Strip mining will affect 1379 acres/year by 2000. Areas surrounding and downwind of energy conversion plants will be subjected to low levels of aerial contaminants over a long period of time. The value of the reclaimed lands will be	Annual Benefits $47,300,000 Annual Adverse Effects $40,410,000	Energy related population increases impact will total an additional 6,520 people by 1985 increasing to a total additional 9,320 people by the year 2000.

Table VII-6. (Cont.). Display of Beneficial and Adverse Effects - Recommended Plan, North Dakota Tributaries

Plan Function/Element	Account			
	National Economic Development	Environmental Quality	Regional Development	Social Well-Being
ENERGY DEVELOPMENT (cont.) Recommended Energy Development Scenario		dependent on the level of success of the reclamation program. Water requirements will total 74,744 AF per year by the year 2000.		
SCENIC AND RECREATION RIVERS				
Yellowstone River (22 miles of free flowing stream)	Capital Cost $3,264,000 Annual Benefits $110,000 Annual Adverse Effects $263,400	Maintain scenic, recreation and wildlife options by preservation of 22 miles of free flowing stream from the Montana State line to the Missouri River.	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be re-regulated by purchase of 8 acres fee title and 4,480 acres of easement.
Knife River (76 miles of free flowing stream)	Capital Cost $12,142,000 Annual Benefits $380,000 Annual Adverse Effects $964,300	Maintain scenic, recreation and wildlife options by preservation of 76 miles of free flowing stream from Manning, North Dakota to the Missouri River.	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be re-regulated by purchase of 76 acres fee title and 16,270 acres of easement.
Heart River (106 miles of free flowing stream)	Capital Cost $16,796,000 Annual Benefits $530,000 Annual Adverse Effects $1,613,100	Maintain scenic recreation and wildlife options by preservation of 106 miles of free flowing stream from Heart Butte Dam to the Missouri River.	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be re-regulated by purchase of 76 acres fee title and 23,320 acres of easement.
Cannonball River (45 miles of free flowing stream)	Capital Cost $7,274,000 Annual Benefits $225,000 Annual Adverse Effects $577,400	Maintain scenic, recreation and wildlife options by preservation of 45 miles of free flowing stream from the county road south of Shields, North Dakota to North Dakota Bridge 1806.	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be re-regulated by purchase of 68 acres fee title and 9,900 acres of easement.

Table VII-6. (Cont.). Display of Beneficial and Adverse Effects - Recommended Plan, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Environmental Quality	Regional Development	Social Well-Being
SCENIC AND RECREATION RIVERS (CONT.)				
Missouri River (75 miles of free flowing stream)	Capital Cost $11,806,000 Annual Benefits $1,237,500 Annual Adverse Effects $1,108,595	Maintain scenic, recreation and wildlife options by preservation of 75 miles of free flowing stream 11 miles downstream from Garrison Dam to the mouth of the Heart River at Fort Lincoln State Park.	Tourism is a major contributor to the area and State economies. Recreation benefits resulting from preservation of these river reaches is in the State/regional interest.	Land ownership and control will be regulated by purchase of 16 acres fee title and 16,500 acres of easement.
INSTREAM FLOW				
Modified Level of Streamflow (see table VII-5)	Not Available	Provide a level of flow not below the following provided natural conditions would permit. North Fork Grand River at Haley 8536 AF/year; Cannonball River at Breien, 68884 AF/year; Little Missouri near Watford City, 186,326 AF/year; Knife River at Hazen, 62,238 AF/year; Heart River near Mandan, 70,628 AF/year These flows would provide for conservation of fish and wildlife.	Not Available	Would place restriction on water use for other purposes.
PRESERVATION				
Unique Woodland Areas	Capital Costs $120,240 Annual Benefits $0* Annual Adverse Effects $8,250 *NED benefits could not be ascertained due to inadequate evaluation techniques.	Provides protection and management of 4,328 acres of ponderosa pine, 735 acres of limber pine and 100 acres of columnar juniper and by administrative action on Federal lands and through acquisition of conservation easements on private land. Preserves the only known areas of such vegetation in North Dakota.	Annual Benefits $0* Annual Adverse Effects $8,250 *Regional dollar benefits could not be ascertained due to inadequate evaluation techniques	Acquisition of conservation easements by Federal, State or local agencies on 3,231 acres of private land, thus preserving current tax base. Educational cultural, and recreational values would be maintained along with preservation of livestock and wildlife cover.

Table VII-6.(Cont.). Display of Beneficial and Adverse Effects - Recommended Plan, North Dakota Tributaries

Plan Function/Element	Account: National Economic Development	Account: Environmental Quality	Account: Regional Development	Account: Social Well-Being
STREAMBANK PROTECTION				
Missouri River, Garrison Dam to Lake Oahe	Capital Costs $7,100,000 Because of the innovative and unproven techniques to be tested in this program, Congress has imposed no requirement for a display of economic feasibility.	Elimination of a major source of sediment which will reduce turbidity levels. Disruption of vegetative cover on quarry sites to be used during construction. Improved water quality for all uses and general esthetics of land and streams.	Stabilization of the location of high river banks along the valley lands reducing risk to dwellings, outbuildings, and cultivation activities.	Protects livelihood of landowners affected.
Yellowstone River, Intake, Montana to mouth	See Montana	State Study Team Report		
HYDRO-ELECTRIC POWER				
Additional Hydroelectric Power at Garrison Dam	Capital Cost $70,000,000 Annual Benefits $9,579,000 Annual Adverse Effects $4,790,000	Increased river stage fluctuations downstream from Garrison Dam. Loss of about 190 acres of terrestrial habitat bordering the river due to a one time bank slope adjustment. This loss will be mitigated by acquisition of 285 acres of similar habitat.	Annual Benefits - Not Available Annual Adverse Effects - Not Available	Retail and service activities stimulated by construction employment of 290 persons. Value of housing temporarily inflated in nearby communities. OM&R employment of 5 persons added.

CHAPTER VIII

RECOMMENDED PLAN EVALUATION

Comparisons of Future Without Plan, Projected Needs and the Recommended Plan

Comparisons of the future without plan, the projected needs, and the conditions with the recommended plan are shown in table VIII-1.

Streambank Erosion Protection

Under existing conditions (1975) 658 miles of streambank are subject to erosion causing an estimated average of $304,000 in damages annually. These damages are expected to increase to $424,000 and $481,300 by 1985 and 2000, respectively. The recommended plan element Knife River Historical Site Protection would provide protection along an 1,800 foot reach of the Knife River.

Flood Control

Under existing conditions (1975), an estimated $2,411,700 of flood damages occur in the area annually. These damages are projected to increase to $2,633,000 and $3,482,700 by 1985 and 2000, respectively. The recommended plan element, Hazen Flood Control, would reduce this level of damage by $40,000 annually. This leaves a remaining need for flood damage protection of $2,593,000 in 1985 and $3,442,700 in the year 2000 for which no feasible plan of alleviation is now evident.

Livestock Water

The BLM has 31 existing livestock impoundments in the area, projected to increase to 42 by the year 2000 which will meet such needs on BLM lands.

Nonenergy Minerals

Mineral developments, such as sand and gravel, nonbentonitic clays, and stone, presently (1975) have a consumptive water requirement of 46 acre-feet annually. This is expected to decline to 43 AF by 1985 and then increase to 52 AF by the year 2000. It is expected that private enterprise will provide this water supply in a manner similar to historical practices and recent trends.

Table VIII-2. Comparison of Future Without Plan, Projected Needs and Conditions With the Recommended Plan

	Existing Condition 1975	Future Without Plan 1985	Future Without Plan 2000	Projected Need or Opportunity 1985	Projected Need or Opportunity 2000	Remaining Need 1985	Remaining Need 2000	Recommended Plan 1985	Recommended Plan 2000	Difference Recommended vs Future Without 1985	Difference Recommended vs Future Without 2000	Projected Need or Opportunity Not Met by Recommended Plan 1985	Projected Need or Opportunity Not Met by Recommended Plan 2000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nonenergy Mineral Water Requirement [illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Water Requirement (AF/Year)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]				
Instream Flow (Acre-Feet)													
North Fork Grand River at Haley	0	0§	0§	[illegible]–8,540	[illegible]–8,540	[illegible]–8,540	[illegible]–8,540	8,540	8,540	+8,540	+8,540		
Cannonball River at Breien				[illegible]–68,890	[illegible]–68,890	[illegible]–68,890	[illegible]–68,890	68,890	68,890	+68,890	+68,890		
Little Missouri River near Watford City		0	0	39,490–186,330	39,490–186,330	39,490–186,330	39,490–186,330	186,330	186,330	+186,330	+186,330		
Knife River at Hazen	0	0	0	11,820–62,240	11,820–62,240	11,820–62,240	11,820–62,240	62,240	62,240	+62,240	+62,240	0	0
Heart River near Mandan	0		0	16,840–70,630	16,840–70,630	16,840–70,630	16,840–70,630	70,630	70,630	+70,630	+70,630	0	
Preservation (Acres)													
Unique Woodland Areas	1,930	1,930	1,930	5,160	5,160	3,230	3,230	5,160	5,160	3,230	3,230	0	0
Streambank Protection (Miles)													
Missouri River, Garrison Dam to Lake Oahe		21	21	21	21	0	0	21	[illegible]	0	0	As Needed	As Needed
Yellowstone River, Intake Montana to mouth		21	21	24	24	0	0	24	24	0	0		
Hydroelectric Power (Megawatts)													
Additional hydro power at Garrison Dam	400	400	400	672	672	[illegible]	272	672	672	+272	+272	0	0
Population (Planning Area)	98,900	131,150	166,520					109,820	119,320	21,330	47,200		

† OBERS Series E

‡ Source: Tables V-3, V-4

§ Instream flow for fishery or other uses not recognized as a beneficial use

* Low figure is the 90% exceedance level; high figure is the modified level from the Northern Great Plains Resource Program in AF/Year

Scenic and Recreation Rivers

The Little Missouri River from the South Dakota State line to the Missouri River is a State scenic and recreation river, so designated by legislative action. Under future without conditions no other rivers would be so designated. However, portions of the Knife, Heart, Cannonball and Yellowstone, rivers totaling 249 miles qualify for such designation. Under the recommended plan, 22 miles of the Yellowstone River, 76 miles of the Knife River, 106 miles of the Heart River and 45 miles of the Cannonball River, are recommended for State designation. In addition, 75 miles of the Missouri River are recommended for designation under the National Wild and Scenic Rivers Act.

Agricultural Production

Agricultural production is projected under the future without plan conditions (see table VIII-1). In order to meet the remaining needs as projected under Series E 46,155 acres of irrigated land above the 1975 level would be required by the year 1985 and 356,997 acres of additional irrigated land would be required by the year 2000.

Irrigation

Under existing (1975) conditions a total of 56,000 acres of lands are being irrigated. Private developments under the without plan are projected to increase this total to 86,000 acres by 1985 and 135,000 acres by the year 2000. These levels or private irrigation were included in the recommended plan. Projected requirements for irrigation total 102,155 acres by the year 1985 and 412,997 acres by the year 2000 leaving an unmet need for irrigation development of 16,155 acres for 1985 and 277,997 acres in the year 2000 under the recommended plan.

Energy Development

Existing (1975) coal production totaled 11 million tons annually. Under future without conditions this was projected to increase to 54.09 million tons by 1985 and to 158.26 million tons by the year 2000. Under the recommended plan

this projected production would be cut to 24 million tons for 1985 and 36 million tons in the year 2000, leaving an unmet need for 30.09 million tons by 1985 and 122.26 million tons by the year 2000. This unmet coal production translates to an unmet need for 5,036 MW of electric generating capacity and 250 mcfd of synthetic gas production by 1985, and 5,036 MW of electric generating capacity and 2,274 mcfd of synthetic gas production by the year 2000.

Instream Flows

Instream flows are not presently recognized as a beneficial use in North Dakota, therefore, under the future without plan conditions, it is expected that instream flows would not be established for the area's streams and the flow levels would continue to decline. However, two levels of streamflow were investigated--a low level equal to the streams 90 percent exceedance levels and a high level based on the modified flows from the Northern Great Plains Resource Program. This high level was included in the recommended plan (table VII-5).

Preservation

Under existing conditions 1,932 acres of unique woodland areas are protected under Federal ownership and an additional 3,231 acres of unique woodland are held in private ownership. All such lands are proposed in the recommended plan for protection by obtaining easements from the present owners.

Streambank Protection

An ongoing streambank protection project along the Missouri River between Garrison Dam and Lake Oahe and along the Yellowstone River between Intake, Montana and the mouth of the river in North Dakota was included in the recommended plan.

Hydroelectric Power

Garrison Dam presently has a hydroelectric generating capacity of 400 megawatts. A proposal to add three units having an installed capacity of 272 megawatts

was included in the recommended plan. A re-regulating structure downstream of the dam was included in this recommendation to facilitate use of the remaining 75-mile reach as a recreation river.

Population

The existing (1975) population for the North Dakota planning area is 98,900. Under the conditions of the recommended plan the population is projected to increase to 109,820 by 1985 and to 119,320 by the year 2000.

Allocation of Recommended Plan Cost

An allocation of costs among plan objectives and among plan purposes was made to determine the magnitude and source of potential repayments. Cost allocations were derived only for those components meeting the evaluation criteria for national economic development. The allocation procedure used was the Separable Costs Remaining Benefits method.

The prospects for meeting repayment and cost sharing requirements must be analyzed at the appraisal level to determine whether or not to proceed with more detailed studies. The allocation of costs for the recommended plan is shown in table VIII-2.

Table VIII-2. Allocation of Costs, Recommended Plan
(Separable Cost Remaining Benefits Method)
(Annual Equivalent, 100-Year, 6-3/8 Percent Interest)

	Energy 1/	Flood Control	Recreation	Fish & Wildlife	Hydro Power	Total
			(thousands $)			
Benefits	$311,800	$ 40	$2,482.5	0	$9,579	$323,901.5
Alternative Costs	------------------------Same as Benefits------------------------					
Justifiable Expenditure	$311,800	$ 40	$2,482.5	0	$9,579	$323,901.5
Separable Costs 3/	$277,310	$ 562 2/	$4,218.9	0	$4,790	$286,880.
Joint Costs 4/	------------------------None------------------------					

1/ Coal-related development.

2/ Includes costs for innovative and unproven techniques for streambank protection.

3/ Includes capital cost, interest during construction and operation, maintenance, and replacement costs.

4/ There are no joint costs; each project included in the Recommended Plan is independent of others.

CHAPTER IX

IMPACT ANALYSIS OF THE RECOMMENDED PLAN

Water Availability and Use

Operations studies were done for each river in the study are to determine the depleted flows based on water requirements of the recommended plan.

The major water requirements are for future irrigation development and instream flow requirements. Future irrigation is water spreading which diverts only during periods of high flows.

Streamflow depletion levels resulting from the recommended plan are shown in tables IX-1 through IX-8. This hydrological analysis provides a check to see if the instream flows in the recommended plan can be met. When the 1975 depletion level flow fell below the recommended instream flow an asterisk (*) appears in the tables. It is obvious from the tables that the recommended instream flows cannot be met much of the time. As an example, the Knife River at Hazen, 1985 level recommended plan, would have an instream flow need of 13,210 acre-feet for April 1974 while the 1985 depleted level flow would be 10,000 acre-feet (table V-9), or a shortage of 3,210 acre-feet. By the year 2000 the depleted flow would be further reduced to 9,540 acre-feet giving a shortage of 3,670 acre-feet at this location for April.

A similar situation exists for the other streams, with shortages from about 30 percent to 80 percent over the period of record depending on the location, year, and month.

One solution to this problem would be to reduce the irrigation allowed from these streams. Another solution would be to reduce the recommended instream flow to a lower level, such as the 90 percent exceedance level flow as presented in table IV-10, or some other exceedance level. More detailed instream flow studies are required on the planning areas streams in order to assist in resolving this problem.

A summary of water related impacts of the recommended plan for each function, project, or program for the period 1975 to 2000 is shown in table IX-9.

Table IX-1. 1[illegible] Recommended Plan Depleted Flow Levels[illegible], and Months of Inadequacy,
Station 6-3405, Knife River at Hazen

Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
							1000 AF					
1930	*1/	*	*	*	51.22	59.10	*	3.68	13.09	*	*	1.49
1931	*	*	*	*	*	*	*	*	*	*	*	7.53
1932	[illegible]	*	*	*	*	*	*	*	12.79	*	*	*
1933	*	2.[illegible]5	*	*	4.02	70.20	*	5.83	*	*	*	*
1934	*	*	*	*	*	*	*	*	*	*	*	*
1935	*	*	*	*	*	*	*	*	*	24.89	*	*
1936	*	*	*	*	*	70.10	*	*	*	*	*	*
1937	*	*	*	*	*	*	19.50	*	58.39	25.29	25.05	*
1938	*	*	*	*	*	26.75	*	4.15	*	58.17	9.37	1.51
1939	1.99	*	*	*	*	87.61	*	*	*	*	*	*
1940	*	*	*	*	*	*	*	4.27	*	5.60	*	*
1941	*	*	*	*	*	*	*	4.42	49.93	*	*	2.90
1942	3.76	*	*	*	*	23.30	21.76	4.68	27.90	*	*	*
1943	*	*	*	*	18.39	195.50	44.93	4.54	25.44	8.73	3.54	2.31
1944	2.45	3.42	2.14	*	*	*	75.39	6.52	60.24	12.39	*	1.69
1945	2.33	3.73	*	1.02	5.24	127.00	*	*	16.62	*	*	*
1946	[illegible]	[illegible]	*	*	5.96	35.48	*	*	*	7.48	*	*
1947	2.40	1.64	*	6.[illegible]	16.12	39.69	44.40	*	49.39	7.24	3.52	*
1948	[illegible]	1.96	1.[illegible]	1.07	*	84.06	45.29	10.68	16.20	*	*	*
1949	1.65	[illegible]	*	*	*	*	125.30	5.51	*	*	*	*
1950	2.24	1.96	*	*	*	22.83	197.40	27.16	*	*	1.89	2.43
1951	2.95	2.16	1.78	1.66	*	40.69	102.90	7.46	*	*	5.66	4.36
1952	3.01	2.20	1.39	1.30	*	*	253.20	6.43	*	4.70	2.01	2.02
1953	2.23	2.32	1.33	1.29	*	*	*	10.47	38.30	*	*	*
1954	1.86	1.54	1.49	1.31	20.65	*	39.69	*	*	*	11.87	6.83
1955	2.39	1.31	1.53	1.13	*	*	*	*	*	*	*	*
1956	*	*	*	*	*	55.14	*	*	*	*	*	*
1957	*	*	*	*	*	23.39	*	*	12.05	4.57	*	*
1958	*	*	1.43	*	*	*	*	*	*	11.08	*	*
1959	*	*	*	*	*	66.35	*	*	*	*	*	*
1960	[illegible]	*	*	*	*	33.46	*	*	*	*	*	*
1961	*	*	*	*	*	*	*	*	*	*	*	*
1962	*	*	*	*	*	*	*	18.35	36.42	18.50	2.71	*
1963	*	*	[illegible]	*	*	*	*	5.35	12.32	*	3.43	*
1964	*	*	*	*	*	*	*	4.24	22.33	11.83	*	2.90
1965	*	*	*	*	*	*	58.96	29.02	17.67	12.33	1.90	1.80
1966	[illegible]	1.58	1.25	*	*	55.27	*	*	44.03	16.22	5.78	*
1967	*	*	*	*	*	120.60	36.80	43.57	11.48	*	*	*
1968	2.13	2.[illegible]	1.60	*	*	22.56	*	*	*	*	4.00	*
1969	*	1.81	1.18	*	*	*	139.20	4.24	*	30.73	5.22	*
1970	2.00	[illegible]	[illegible]	*	*	*	15.03	93.00	20.44	7.89	4.33	1.98
1971	2.26	1.05	2.00	1.17	5.31	30.42	31.55	6.20	41.77	*	*	2.50
1972	2.63	*	*	1.44	*	137.05	17.93	21.75	25.83	*	5.63	2.08
1973	[illegible]	2.77	[illegible]	4.10	8.23	51.58	*	3.53	*	*	*	*
1974	*	1.62	1.43	3.34	12.73	20.79	*	7.52	*	*	*	*
1975	*	*	1.24	*	*	*	110.53	46.99	15.62	6.41	2.70	1.55
Instream Flow Level Recommended Plan	1.60	[illegible]	1.17	0.95	[illegible]	19.43	13.21	3.26	9.94	4.49	1.72	1.49

1/ When the 1970 level flows fall below instream flow requirements the table indicates this by showing an asterisk (*).

Table [illegible] Recommended Plan Depleted Flow Levels, and Months of Inadequacy, Station [illegible]-0475, Knife River at Hazen

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
							(1000 AF)					
1930	*1/	*	*	*	51.22	55.58	*	3.54	12.56	*	*	*
1931	*	*	*	*	*	*	*	*	*	*	*	7.53
1932	[illegible]	*	*	*	*	*	*	*	12.56	*	*	*
1933	*	[illegible]	*	*	4.02	69.68	*	5.69	*	*	*	*
1934	*	*	*	*	*	*	*	*	*	*	*	*
1935	*	*	*	*	*	*	*	*	*	24.39	*	*
1936	*	*	*	*	*	29.55	*	*	*	*	*	*
1937	*	*	*	*	*	*	19.04	*	98.75	25.29	26.[illegible]5	*
1938	*	*	*	*	*	26.23	*	4.01	*	58.17	9.87	1.51
1939	1.09	*	*	*	*	37.09	*	*	*	*	*	*
1940	*	*	*	*	*	*	*	4.13	*	5.60	*	*
1941	*	*	*	*	*	*	*	4.28	49.70	*	*	2.32
1942	[illegible]	*	*	*	*	22.75	[illegible].00	4.54	27.67	*	*	*
1943	*	*	*	*	18.09	194.98	44.47	4.40	25.21	3.73	3.54	2.31
1944	2.46	[illegible]	[illegible]	*	*	*	74.93	6.38	60.01	12.39	*	1.69
1945	[illegible]	[illegible]	*	[illegible]	[illegible]	126.48	*	*	16.09	4.49	*	*
1946	[illegible]	[illegible]	*	*	[illegible]	34.96	*	*	*	7.48	*	*
1947	[illegible]	[illegible]	*	[illegible]	[illegible]	39.17	43.94	*	49.16	7.24	3.52	*
1948	[illegible]	[illegible]	[illegible]	[illegible]	*	33.54	44.33	10.54	15.97	*	*	*
1949	[illegible]	[illegible]	*	*	*	*	124.84	5.37	*	*	*	*
1950	[illegible]	1.96	*	*	*	22.31	196.94	27.02	*	*	1.89	2.43
1951	[illegible]	[illegible]	[illegible]	[illegible]	*	40.17	102.44	7.32	*	*	5.66	4.36
1952	[illegible]	[illegible]	[illegible]	[illegible]	*	*	202.74	6.29	*	4.70	2.01	2.02
1953	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	10.33	[illegible]	*	*	*
1954	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	39.23	*	*	*	11.87	6.53
1955	[illegible]	[illegible]	[illegible]	[illegible]	*	*	*	*	*	*	*	*
1956	*	*	*	*	*	54.62	*	*	*	*	*	*
1957	*	*	*	*	*	22.87	*	*	11.82	4.57	*	*
1958	*	*	[illegible]	*	*	*	*	*	*	11.08	*	*
1959	*	*	*	*	*	65.93	*	*	*	*	*	*
1960	[illegible]	*	*	*	*	30.34	*	*	*	*	*	*
1961	*	*	*	*	*	*	*	*	*	*	*	*
1962	*	*	*	*	*	*	*	13.21	26.19	18.00	2.71	*
1963	*	*	[illegible]	*	*	*	*	5.71	12.59	*	3.43	*
1964	*	*	*	*	*	*	*	4.10	22.10	11.33	*	2.20
1965	*	*	*	*	*	*	55.50	28.88	16.94	12.33	1.90	1.80
1966	[illegible]	[illegible]	[illegible]	*	*	84.75	*	*	43.90	16.22	5.78	*
1967	*	*	*	*	*	120.18	36.04	[illegible]	11.25	*	*	*
1968	[illegible]	[illegible]	[illegible]	*	*	22.04	*	*	*	*	4.00	*
1969	*	[illegible]	[illegible]	*	*	*	[illegible]	4.70	*	30.73	5.22	*
1970	[illegible]	[illegible]	[illegible]	*	*	*	34.57	33.36	20.21	7.89	4.33	1.98
1971	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73.91	[illegible]	6.26	41.64	*	*	2.50
1972	[illegible]	*	*	[illegible]	*	126.52	11.48	21.61	25.50	*	5.63	2.08
1973	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51.05	*	3.39	*	*	*	*
1974	*	[illegible]	[illegible]	[illegible]	[illegible]	20.26	*	7.09	*	*	*	*
1975	*	*	[illegible]	*	*	*	112.07	46.95	15.39	6.41	2.70	1.55
Instream Flow Recommendation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19.41	3.21	3.26	9.94	4.49	1.72	1.49

1/ When the 1975 level flows fall below instream flow requirements the table indicates this by showing an asterisk (*).

Table IX-3. 1975 Recommended Plan Depleted Flow Levels, and Months of Inadequacy, Station 6-3490, Heart River at Mandan

YEAR	OCT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP		
					(1000 AF)							
1929	*[1]	*	*	*	*	28.56	17.44	6.33	32.50	*	*	*
1930	*	2.94	*	*	17.82	66.60	25.14	7.16	15.00	8.68	*	*
1931	*	*	*	0.91	6.31	*	*	*	*	*	*	*
1932	*	*	*	*	5.75	*	*	*	11.60	7.29	*	*
1933	*	3.00	*	*	*	46.96	*	10.21	*	6.47	*	*
1934	*	*	*	*	*	*	*	*	*	*	*	*
1935	*	*	*	*	*	*	*	*	11.60	7.97	*	*
1936	*	*	*	*	*	*	*	*	*	*	*	*
1937	*	*	*	*	*	*	*	*	47.50	19.67	*	*
1938	*	*	*	*	*	*	*	*	13.93	52.61	*	*
1939	*	2.75	*	*	*	50.36	18.74	7.41	13.09	6.08	*	*
1940	*	*	*	*	*	17.40	*	7.88	*	*	*	*
1941	*	*	*	*	*	25.56	*	9.48	72.70	*	*	*
1942	4.12	*	*	*	*	*	20.20	16.72	26.79	7.70	*	*
1943	*	*	*	*	19.95	143.06	95.05	49.84	57.72	45.67	4.84	*
1944	*	3.78	*	*	*	*	77.34	42.95	65.84	29.63	*	*
1945	*	4.39	*	*	9.21	97.06	75.71	32.70	13.69	*	*	*
1946	*	*	*	*	*	21.18	14.46	*	*	6.29	*	*
1947	*	*	*	*	14.79	37.94	51.33	46.86	51.95	17.55	5.29	*
1948	*	*	*	*	*	101.46	60.15	50.85	13.52	14.08	5.76	*
1949	*	*	*	*	*	52.65	121.64	28.65	17.63	*	*	*
1950	*	*	*	*	*	*	382.94	85.33	19.44	*	*	*
1951	*	*	*	0.93	*	81.37	120.84	10.21	*	10.03	8.86	7.10
1952	5.29	4.38	*	*	*	*	332.74	14.03	9.94	10.27	7.00	8.58
1953	4.73	5.36	*	*	*	*	*	9.28	35.15	10.72	5.32	5.25
1954	5.66	*	4.73	3.48	13.41	*	61.14	13.36	*	*	*	4.05
1955	*	*	1.62	*	*	*	*	*	*	6.23	*	*
1956	*	3.26	3.06	2.12	1.32	47.24	17.44	8.76	*	3.32	*	*
1957	3.63	5.48	1.78	*	*	*	*	*	*	13.87	*	*
1958	*	3.72	1.70	*	*	*	16.86	*	*	*	*	*
1959	*	*	*	*	*	62.05	25.10	*	*	*	*	*
1960	3.50	*	*	0.81	*	36.89	16.73	*	14.18	*	*	*
1961	*	*	*	*	*	*	*	*	9.82	*	*	*
1962	*	*	*	*	*	*	*	8.89	12.14	6.49	*	*
1963	*	*	*	*	*	*	*	*	*	6.48	8.74	*
1964	*	*	*	*	*	*	*	*	24.17	33.45	*	*
1965	*	*	*	*	*	*	40.44	31.31	33.83	*	5.35	6.64
1966	4.92	*	2.13	*	*	99.16	14.75	5.03	60.01	38.08	7.78	4.56
1967	3.62	*	1.63	1.23	*	119.06	46.91	108.11	10.31	*	6.01	5.01
1968	*	*	1.56	*	*	*	*	*	*	*	6.35	3.87
1969	*	*	*	*	*	*	255.44	11.04	*	74.26	6.62	6.27
1970	*	*	1.34	0.37	*	*	32.97	221.31	33.37	15.16	10.00	6.38
1971	3.41	*	*	*	1.53	102.06	70.55	18.43	35.47	12.64	5.60	6.01
1972	3.65	*	1.90	1.44	*	169.93	50.45	69.37	55.18	15.68	10.69	6.48
1973	*	2.97	2.24	3.21	15.77	85.94	*	8.02	*	*	5.14	*
1974	*	*	1.98	2.77	4.40	*	*	*	*	*	*	*
1975	*	*	*	*	*	*	131.90	123.25	26.45	12.08	7.91	*
Instream Flow Level Recommended Plan	3.38	2.50	1.54	0.80	1.28	17.40	14.46	4.37	9.82	5.90	4.74	3.87

[1] When the 1975 level flows fall below instream flow requirements, the table indicates this by showing an asterisk (*).

Table IX-4. 2000 Recommended Plan Depleted Flow Levels, and Months of Inadequacy,
Station 6-3490, Heart River at Mandan

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
							1000 AF					
1929	*1/	*	*	*	*	36.05	16.30	6.42	32.26	*	*	*
1930	*	2.34	*	*	17.82	66.09	24.60	6.95	14.76	8.68	*	*
1931	*	*	*	1.91	6.31	*	*	*	*	*	*	*
1932	*	*	*	*	5.76	*	*	*	11.36	7.29	*	*
1933	*	3.00	*	*	*	46.45	*	10.00	*	6.47	*	*
1934	*	*	*	*	*	*	*	*	*	*	*	*
1935	*	*	*	*	*	*	*	*	11.36	7.97	*	*
1936	*	*	*	*	*	*	*	*	*	*	*	*
1937	*	*	*	*	*	*	*	*	47.26	19.67	*	*
1938	*	*	*	*	*	*	*	*	13.69	52.61	*	*
1939	*	2.75	*	*	*	49.85	18.20	7.20	12.85	6.08	*	*
1940	*	*	*	*	*	*	*	7.67	*	*	*	*
1941	*	*	*	*	*	26.05	*	9.27	72.46	*	*	*
1942	[illegible]	*	*	*	*	*	19.66	16.51	26.55	7.70	*	*
1943	*	*	*	*	19.95	142.55	94.51	49.63	57.48	45.67	4.84	*
1944	*	3.78	*	*	*	*	76.80	42.74	65.60	29.63	*	*
1945	*	4.12	*	*	9.21	36.55	75.17	32.49	13.45	*	*	*
1946	*	*	*	*	*	20.57	*	*	*	6.29	*	*
1947	*	*	*	*	4.79	37.43	50.79	46.65	51.71	17.55	5.29	*
1948	*	*	*	*	*	100.95	59.61	50.64	13.28	14.08	5.76	*
1949	*	*	*	*	*	52.14	121.10	28.44	17.39	*	*	*
1950	*	*	*	*	*	*	382.40	35.12	19.20	*	*	*
1951	*	*	*	.93	*	60.36	120.30	10.00	*	10.03	8.36	7.10
1952	5.19	4.08	*	*	*	*	332.20	13.82	*	10.27	7.00	8.58
1953	4.73	5.36	*	*	*	*	*	9.07	34.91	10.72	5.32	5.25
1954	5.66	*	4.71	3.43	13.41	*	60.60	13.15	*	*	*	4.05
1955	*	*	1.60	*	*	*	*	*	*	6.23	*	*
1956	*	3.25	3.06	2.12	1.32	46.73	16.90	8.55	*	6.32	*	*
1957	3.80	5.48	1.78	*	*	*	*	*	*	13.87	*	*
1958	*	3.72	1.72	*	*	*	16.32	*	*	*	*	*
1959	*	*	*	*	*	61.54	24.56	*	*	*	*	*
1960	[illegible]	*	*	1.61	*	36.38	16.19	*	13.94	*	*	*
1961	*	*	*	*	*	*	*	*	*	*	*	*
1962	*	*	*	*	*	*	*	8.68	11.90	6.49	*	*
1963	*	*	*	*	*	*	*	*	*	6.43	8.74	*
1964	*	*	*	*	*	*	*	*	23.93	38.45	*	*
1965	*	*	*	*	*	*	39.90	31.10	33.59	*	5.35	6.64
1966	4.91	*	[illegible]	*	*	98.65	*	4.82	59.77	38.08	7.78	4.56
1967	3.60	*	[illegible]	.13	*	118.55	46.37	107.90	10.07	*	6.01	5.01
1968	*	*	1.36	*	*	*	*	*	*	*	6.35	*
1969	*	*	*	*	*	*	254.90	10.83	*	74.26	6.62	6.27
1970	*	*	1.44	.97	*	*	32.43	221.10	33.13	15.16	10.00	6.38
1971	3.41	*	*	*	1.53	101.55	70.01	18.22	35.23	12.64	5.60	6.01
1972	3.63	*	.90	1.44	*	169.42	49.91	69.16	54.94	15.68	10.69	6.48
1973	*	2.47	3.24	3.21	15.77	35.43	*	7.31	*	*	5.14	*
1974	*	*	1.38	2.77	4.40	*	*	*	*	*	*	*
1975	*	*	*	*	*	*	131.36	103.04	36.21	12.08	7.91	*
Instream Flow Level Recommended Plan	2.04	2.60	1.64	1.60	1.23	17.40	14.46	4.37	9.32	5.90	4.74	3.37

1/ When the 1975 level flows fall below instream flow requirements, the table indicates this by showing an asterisk *.

Table IX-[illegible]. 1985 Recommended Plan Depleted Flow Levels, and Months of Inadequacy.
Station 6-3540, Cannonball River at Breien

(1000 AF)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1929	*1	*	*	0.41	*	130.64	20.99	*	28.15	*	*	*
1930	1.25	*	*	*	22.76	45.04	*	*	*	*	*	*
1931	*	*	*	0.81	2.46	*	*	*	*	*	*	*
1932	*	*	*	*	11.76	31.94	*	*	47.35	*	*	*
1933	*	*	*	*	*	45.84	*	*	*	*	*	*
1934	*	*	*	*	*	*	*	*	*	*	*	*
1935	*	*	*	*	*	*	*	*	*	17.56	*	*
1936	*	*	*	*	*	32.84	*	*	*	*	*	*
1937	*	*	*	*	*	*	16.29	*	138.95	13.06	*	4.90
1938	*	*	*	0.41	*	20.44	*	*	29.35	72.06	*	3.10
1939	*	*	0.71	*	*	41.24	*	*	*	8.36	*	*
1940	*	*	*	*	*	*	14.99	16.39	*	*	4.31	*
1941	*	*	*	*	*	51.84	*	*	83.05	*	*	2.40
1942	2.05	*	*	*	*	*	15.29	21.69	*	*	*	1.10
1943	*	*	*	*	17.46	275.44	66.89	*	46.75	30.16	1.81	1.40
1944	*	2.22	0.91	0.61	*	*	196.09	*	82.45	25.66	1.61	1.60
1945	1.55	4.32	1.21	0.61	13.06	82.64	*	*	16.35	*	*	1.20
1946	*	*	0.81	*	*	*	*	*	*	9.36	*	.90
1947	3.55	1.42	*	0.61	24.96	52.54	56.59	*	54.55	13.66	*	*
1948	2.25	1.92	1.21	1.11	2.26	141.94	15.49	*	*	6.46	3.31	*
1949	*	1.52	*	*	*	106.64	128.49	17.59	*	*	2.31	*
1950	1.25	*	*	*	*	*	597.19	69.09	16.15	*	10.61	3.50
1951	3.25	2.52	1.31	1.61	4.06	106.04	28.89	*	20.55	*	10.91	9.10
1952	4.15	2.92	1.51	0.61	*	*	427.79	11.89	*	11.26	4.11	4.20
1953	*	1.22	1.01	0.81	*	*	*	47.59	87.15	9.56	4.41	1.10
1954	1.25	1.82	1.51	0.61	4.56	*	29.09	*	*	*	2.61	7.80
1955	*	*	0.81	*	*	*	*	*	*	6.36	3.01	2.30
1956	*	*	*	*	*	87.64	*	*	*	*	3.61	2.30
1957	*	2.22	0.91	0.51	*	*	*	*	43.65	14.76	2.61	1.00
1958	1.05	1.82	1.31	0.41	*	*	16.19	*	24.35	*	*	*
1959	*	*	*	*	*	68.54	*	*	*	*	*	*
1960	*	*	*	*	*	33.24	*	*	*	*	*	*
1961	*	*	*	*	*	*	*	*	*	*	*	1.50
1962	*	*	*	*	*	*	*	16.09	35.75	8.46	4.61	1.30
1963	*	*	*	*	*	*	*	*	*	*	*	*
1964	*	*	*	*	*	*	*	*	71.15	8.66	*	*
1965	*	*	*	*	*	*	45.59	26.39	24.75	*	1.91	1.60
1966	1.15	*	0.81	*	*	141.24	16.79	*	20.55	36.66	4.51	.90
1967	1.05	1.02	1.11	0.71	5.06	54.54	15.29	74.39	*	*	*	*
1968	*	*	0.71	*	*	*	*	*	*	*	1.91	*
1969	*	*	*	*	*	58.14	171.09	*	*	36.06	6.61	*
1970	*	1.52	1.31	0.71	*	*	31.19	118.49	25.75	5.54	7.51	1.30
1971	*	2.70	1.51	0.95	3.22	152.84	92.14	15.93	45.38	22.07	4.35	*
1972	5.39	2.85	2.04	1.26	*	216.65	30.93	140.51	41.69	14.58	10.30	3.49
1973	4.61	3.84	1.48	21.02	20.83	48.41	15.85	8.48	*	*	*	2.01
1974	2.74	1.23	1.31	2.37	7.13	*	*	*	*	*	*	*
1975	*	*	*	*	*	*	99.38	147.11	20.38	11.41	5.73	1.45
Instream Flow Level Recommended Plan	1.95	1.07	0.65	0.37	2.16	19.25	13.96	7.93	14.04	5.54	1.54	0.39

1 When the 1975 level flows fall below instream flow requirements, the table indicates this by showing an asterisk (*).

Table IX-6. LCD Recommended Plan Depleted Flow Levels, and Months of Inadequacy,
Station R-3540, Cannonball River at Breien

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1929	*	*	*	0.41	*	100.33	20.67	*	27.99	*	*	*
1930	1.05	*	*	*	22.75	44.73	*	*	*	*	*	*
1931	*	*	*	1.81	12.46	*	*	*	*	*	*	*
1932	*	*	*	*	11.76	31.63	*	*	47.19	*	*	*
1933	*	*	*	*	*	45.63	*	*	*	*	*	*
1934	*	*	*	*	*	*	*	*	*	*	*	*
1935	*	*	*	*	*	*	*	*	*	17.66	*	*
1936	*	*	*	*	*	32.63	*	*	*	*	*	*
1937	*	*	*	*	*	*	15.97	*	138.73	13.06	*	4.90
1938	*	*	*	0.41	*	10.73	*	*	29.19	72.06	*	3.10
1939	*	*	--	*	*	40.93	*	*	*	8.36	*	*
1940	*	*	*	*	*	*	14.67	16.03	*	*	4.31	*
1941	*	*	*	*	*	51.53	*	*	82.39	*	*	2.40
1942	2.05	*	*	*	*	*	14.97	21.62	*	*	*	1.10
1943	*	-	*	*	17.46	275.13	66.57	*	46.59	30.16	1.81	1.40
1944	*	2.00	1.81	.61	*	*	135.77	*	32.09	25.66	1.61	1.60
1945	1.65	2.00	[illegible]	.61	13.06	32.33	*	*	16.19	*	*	1.00
1946	*	*	1.81	*	*	*	*	*	*	9.36	*	.90
1947	1.65	1.41	*	1.61	14.36	52.23	56.27	*	54.39	13.66	*	*
1948	2.05	1.61	1.21	1.11	1.26	141.63	13.11	*	*	6.46	3.31	*
1949	*	1.61	-	*	*	106.33	109.17	17.49	*	*	2.31	*
1950	1.05	*	*	*	*	*	596.57	66.38	15.99	*	10.61	3.60
1951	3.05	2.60	1.81	1.61	4.05	105.73	29.67	*	20.39	*	10.91	9.10
1952	4.15	2.00	1.61	1.61	*	*	427.47	11.73	*	11.05	4.11	4.20
1953	*	[illegible]	[illegible]	[illegible]	*	*	*	47.49	36.99	9.66	4.41	1.10
1954	1.05	1.00	1.61	1.61	4.66	*	29.77	*	*	*	2.61	1.80
1955	*	*	[illegible]	*	*	*	*	*	*	6.36	3.01	2.30
1956	*	*	*	*	*	57.33	*	*	*	*	3.61	2.30
1957	*	1.00	1.81	1.01	*	*	*	*	43.49	14.76	2.61	1.00
1958	1.05	1.60	[illegible]	1.41	*	*	15.97	*	24.19	*	*	*
1959	*	*	*	*	*	66.23	*	*	*	*	*	*
1960	*	*	*	*	*	32.93	*	*	*	*	*	*
1961	*	*	*	*	*	*	*	*	*	*	*	1.50
1962	*	*	*	*	*	*	*	15.93	36.59	8.46	4.61	1.30
1963	*	*	*	*	*	*	*	*	*	*	*	*
1964	*	*	*	*	*	*	*	*	70.99	6.66	*	*
1965	*	*	*	*	*	*	46.27	26.33	24.59	*	1.91	1.60
1966	[illegible]	*	[illegible]	*	*	140.93	16.47	*	20.39	36.66	4.61	.90
1967	[illegible]	[illegible]	[illegible]	[illegible]	6.06	54.23	14.97	24.03	*	*	*	*
1968	*	*	[illegible]	*	*	*	*	*	*	*	1.91	*
1969	*	*	*	*	*	57.63	170.77	*	*	35.00	6.61	*
1970	*	[illegible]	[illegible]	[illegible]	*	*	30.57	116.03	25.69	*	7.51	1.30
1971	*	[illegible]	[illegible]	.95	2.22	152.63	97.82	15.81	45.22	22.07	4.35	*
1972	6.12	2.46	2.14	1.26	*	216.74	30.62	140.40	41.53	14.58	10.30	3.49
1973	4.61	[illegible]	1.41	21.00	[illegible]	46.77	15.53	8.37	*	*	*	2.01
1974	[illegible]	[illegible]		[illegible]	[illegible]	*	*		*	*	*	*
1975	*	*	*	*	*	*	39.06	147.00	20.22	11.41	5.73	1.45
Instream Flow Level Recommended Plan	.95	.77	[illegible]	1.07	1.16	19.05	10.86	7.93	14.04	5.54	1.54	0.89

1/ When the 1975 level flows fall below instream flow requirements, the table indicates this by showing an asterisk (*).

Table IX-7. 1985 Recommended Plan Depleted Flow Levels, and Months of Inadequacy, Station 6-3370, Little Missouri at Watford City

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
							(1000 AF)					
1929	4.88	3.07	0.33	0.31	*	426.26	250.46	218.53	253.74	*	*	3.77
1930	14.98	3.37	1.53	0.91	75.56	68.36	*	*	92.34	*	10.07	37.27
1931	*	*	1.53	1.61	12.46	*	*	*	*	18.24	35.97	15.47
1932	7.28	4.27	1.73	0.91	*	68.26	136.86	49.72	99.24	46.24	*	3.97
1933	9.48	9.37	1.73	0.41	*	166.16	50.66	195.13	*	*	*	*
1934	*	*	*	0.41	*	*	*	*	*	*	*	*
1935	*	*	*	0.21	*	*	*	*	36.34	105.74	*	*
1936	*	*	*	0.20	*	137.36	52.71	*	*	*	*	*
1937	*	*	*	0.21	*	*	44.37	*	139.54	66.78	83.28	11.80
1938	5.26	*	*	0.21	*	174.36	*	*	59.19	72.18	7.93	13.44
1939	*	*	0.70	0.56	*	190.56	*	*	38.00	45.98	*	*
1940	*	*	*	0.25	*	*	41.38	20.05	*	17.64	21.28	18.34
1941	14.46	*	*	0.23	*	*	34.67	*	180.74	*	21.33	68.20
1942	27.58	3.59	1.68	0.23	*	110.36	47.97	66.33	92.24	*	*	7.75
1943	*	2.19	0.60	0.64	167.96	195.56	65.77	*	59.57	48.03	22.60	6.54
1944	*	3.07	*	0.35	*	*	490.26	39.75	327.44	51.27	12.51	5.88
1945	*	5.74	*	0.21	*	301.66	30.66	*	*	*	*	5.02
1946	5.43	*	*	0.35	15.70	*	*	*	39.80	25.99	*	7.55
1947	60.32	24.43	8.60	4.39	77.81	363.86	226.86	*	153.64	71.45	35.68	*
1948	*	*	1.00	0.24	14.87	185.06	62.05	21.91	52.74	61.42	20.57	*
1949	*	3.50	2.75	0.24	*	346.56	217.46	*	*	*	*	*
1950	6.06	2.45	1.57	0.11	*	72.60	449.96	122.73	*	*	13.54	7.57
1951	4.54	*	*	0.11	15.89	113.46	30.33	*	*	*	8.70	29.51
1952	7.76	2.40	1.91	0.36	*	*	718.76	*	*	*	*	*
1953	*	*	*	*	*	*	*	58.80	107.94	*	16.00	11.62
1954	5.90	3.02	0.85	*	28.60	*	83.24	*	36.17	*	31.24	30.32
1955	*	*	*	0.16	*	*	32.31	41.27	55.79	22.48	*	*
1956	*	*	*	*	*	*	*	*	34.69	23.32	26.37	*
1957	*	*	*	0.10	*	*	*	*	52.59	22.97	*	20.10
1958	*	2.99	1.64	*	*	*	*	*	38.64	49.02	*	*
1959	*	*	*	*	*	239.76	34.46	*	34.69	*	*	9.50
1960	4.87	*	1.10	0.16	*	218.46	*	*	52.11	*	*	*
1961	*	*	*	*	*	*	*	*	*	*	*	10.52
1962	*	*	*	*	*	*	*	102.93	154.04	71.80	15.38	*
1963	7.11	2.56	0.35	0.07	25.83	115.16	60.84	33.21	108.34	19.20	9.32	14.11
1964	*	*	*	*	*	*	*	*	75.30	38.03	16.74	11.69
1965	*	*	*	0.13	*	*	233.36	95.44	64.65	75.80	8.22	13.06
1966	*	2.16	1.09	0.26	*	121.66	*	*	*	35.87	8.14	*
1967	*	*	*	0.11	*	155.36	60.27	208.53	140.14	17.34	*	12.98
1968	7.17	2.41	1.55	0.21	*	86.90	*	*	*	*	20.39	5.86
1969	*	2.00	0.65	0.13	*	225.66	177.96	83.44	37.87	70.34	13.40	*
1970	*	*	0.57	0.24	*	*	76.05	122.73	91.36	*	10.75	3.71
1971	*	3.41	1.10	0.19	33.09	427.06	281.76	42.43	304.54	41.58	*	33.13
1972	146.55	20.36	4.07	3.65	*	526.06	53.47	139.06	70.10	30.49	34.39	6.29
1973	5.36	2.98	0.96	1.43	37.31	110.39	*	22.10	62.47	*	*	21.07
1974	7.08	4.09	1.89	5.40	*	*	39.01	66.76	44.16	*	*	*
1975	*	3.04	*	*	*	*	230.53	263.56	61.50	42.75	*	*
Instream Flow Level Recommended Plan	4.18	1.67	0.49	0.06	10.07	57.75	29.57	13.39	34.59	16.61	7.50	3.51

1/ When the 1985 level flows fall below instream flow requirements, the table indicates this by showing an asterisk (*).

Table I - [illegible] Recommended Plan Depleted Flow Levels, and Months of Inadequacy, Station 6-[illegible], Little Missouri at Watford City

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
[illegible]	4.93	3.07	1.13	2.27	10.17	408.14	249.74	216.17	362.16	*	*	3.77
[illegible]	14.33	3.07	1.61	2.21	75.56	87.96	29.57	*	31.75	*	10.17	37.27
[illegible]	*	*	1.53	[illegible]	11.45	*	29.57	*	*	15.24	35.97	15.47
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	150.16	105.14	43.17	95.66	46.14	*	3.97
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	135.25	61.34	194.17	*	*	*	*
[illegible]	*	[illegible]	*	[illegible]	*	*	29.57	[illegible]	*	*	*	*
[illegible]	*	*	*	[illegible]	*	*	29.57	*	35.79	105.74	*	*
[illegible]	*	*	*	[illegible]	*	116.95	57.99	*	*	*	*	*
[illegible]	*	*	*	[illegible]	*	*	43.66	*	133.95	66.73	83.29	11.30
[illegible]	1.05	*	*	[illegible]	*	110.45	29.57	*	53.60	72.13	7.93	13.44
[illegible]	*	*	[illegible]	[illegible]	*	189.56	29.57	*	37.47	45.99	*	*
[illegible]	*	*	*	[illegible]	*	*	40.66	19.99	*	17.54	31.39	18.34
[illegible]	[illegible]	*	*	[illegible]	*	*	39.95	*	180.15	*	21.33	68.20
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	118.96	47.26	66.47	57.56	*	*	7.75
[illegible]	*	[illegible]	[illegible]	[illegible]	157.95	124.56	65.26	*	58.96	46.03	22.50	6.54
[illegible]	*	[illegible]	*	[illegible]	*	*	489.64	39.09	325.65	57.17	10.67	5.86
[illegible]	*	[illegible]	*	[illegible]	*	100.75	29.57	*	*	*	*	5.02
[illegible]	[illegible]	*	*	[illegible]	[illegible]	*	29.57	*	89.17	26.99	*	7.55
[illegible]	[illegible]	14.40	[illegible]	[illegible]	[illegible]	260.86	195.14	*	150.15	47.45	35.68	*
[illegible]	*	*	*	[illegible]	14.67	164.16	261.23	21.65	52.15	61.42	20.67	*
[illegible]	*	[illegible]	[illegible]	[illegible]	*	348.75	216.74	*	*	*	*	*
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	101.60	449.21	100.37	*	*	13.64	7.57
[illegible]	[illegible]	*	*	[illegible]	[illegible]	112.56	29.57	*	*	*	9.70	29.51
[illegible]	[illegible]	[illegible]	*	[illegible]	*	*	[illegible]	*	*	*	*	*
[illegible]	*	*	[illegible]	*	*	*	29.57	68.44	37.05	*	16.00	11.62
[illegible]	*	[illegible]	*	*	[illegible]	*	40.50	*	35.59	*	31.24	30.32
[illegible]	*	*	*	*	*	*	51.53	40.37	55.79	22.49	*	*
[illegible]	*	*	*	*	*	*	*	*	*	19.33	26.07	*
[illegible]	*	*	*	*	*	*	*	*	60.00	[illegible]	*	20.10
[illegible]	*	1.93	[illegible]	*	*	*	*	*	37.05	49.02	*	*
[illegible]	*	*	*	*	*	109.65	10.74	*	*	*	*	9.50
[illegible]	[illegible]	*	*	[illegible]	*	[illegible]	*	*	61.00	*	*	*
[illegible]	*	*	*	*	*	*	*	*	*	*	*	10.52
[illegible]	*	*	*	*	*	*	*	100.57	150.45	11.80	16.99	*
[illegible]	[illegible]	[illegible]	*	[illegible]	[illegible]	114.16	60.12	30.25	101.75	19.00	3.22	14.11
[illegible]	*	*	*	*	*	*	*	*	74.11	59.03	16.71	11.69
[illegible]	*	*	*	[illegible]	*	*	232.64	[illegible]	14.06	75.60	3.00	13.06
[illegible]	*	[illegible]	[illegible]	[illegible]	*	[illegible]	*	*	*	36.47	3.14	*
[illegible]	*	*	*	[illegible]	*	64.96	64.55	209.17	109.55	17.34	*	12.99
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	[illegible]	*	*	*	*	30.99	6.38
[illegible]	*	[illegible]	[illegible]	[illegible]	*	224.75	177.14	80.09	37.09	72.34	13.40	*
[illegible]	*	*	[illegible]	[illegible]	[illegible]	*	75.64	112.67	[illegible]	*	10.75	3.77
[illegible]	*	[illegible]	[illegible]	[illegible]	20.19	406.13	281.14	421.07	303.96	47.53	*	33.13
[illegible]	[illegible]	21.06	[illegible]	[illegible]	*	605.16	50.75	[illegible]	59.57	30.49	34.99	6.09
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	173.43	*	[illegible]	61.97	*	*	21.07
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	*	133.23	66.40	43.67	*	*	*
[illegible]	*	[illegible]	*	[illegible]	*	*	[illegible]	[illegible]	[illegible]	43.79	*	*
Instream Flow Level Recommended Plan	4.13	1.67	[illegible]	1.06	[illegible]	57.75	29.57	15.09	34.69	16.61	7.60	3.57

1/ When the 1975 level flows fall below instream flow requirements, the table indicates this by showing an asterisk *.

Showing Net Change From Existing (1975) Conditions to the Year 2000,
North Dakota Tributaries

Function/Project or Program	WATER UTILIZATION: Surface Water Acre-Feet: Diversion	Surface Water Acre-Feet: Depletion	Ground Water Acre-Feet: Diversion	Ground Water Acre-Feet: Depletion	STORAGE (acre-feet): Sediment and Dead	Flood Control	Irrigation	Hydro-Power	Recreation	Fish and Wildlife	Instream Flow	Municipal	Industrial
Streambank Erosion Protection Knife River Historic Site	0	0	0	0	0	0	0	0	0	0	0	0	0
Flood Control Hazen Project	0	0	0	0	0	0	0	0	0	0	0	0	0
Livestock Water BLM Impoundments	504	504	0	0	0	0	0	0		0	0	0	0
Non-Energy Minerals	205 1/	6 1/	0	0	0	0	0	0	0	0	0	0	0
Scenic and Recreation Rivers (Knife, Heart, Cannonball, Missouri and Yellowstone)	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural Production	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation (Private)	21,500 2/	21,500 2/	57,600 2/	57,600 2/	0	0	0	0	0	0	0	0	0
Energy Development	42,124	42,124	0	0	0	0	0	0	0	0	0	0	0
Instream Flow (Grand, Cannonball, Little Missouri, Knife, and Heart Rivers)	396,612	-	0	0	0	0	0	0	0	0	0	0	0
Preservation Unique Woodland Areas	0	0	0	0	0	0	0	0	0	0	0	0	0
Streambank Protection (Missouri and Yellowstone Rivers)	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydro-Electric Power	4/	0	0	0	0	0	0	0	0	0	0	0	0
Population	3,862 3/	1,931 3/	1/	1/	0	0	0	0	0	0	0	0	0

1/ An undetermined portion would be provided by ground water.

2/ Assumes 0.5 AF per acre depletion for waterspreadings and a depletion of 1.6 AF/acre for ground water, the figures reflect an increase from 7,000 to 43,000 acres using ground water and 49,000 to 92,000 acres using surface water.

3/ Assumes 185 gallons per capita and a diversion equal to twice the depletion.

4/ Undetermined.

Land Use Changes

Land use impacts of the recommended plan for the period 1975 to the year 2000 are shown in table IX-10.

The major land use change over this period will result from the projected development of private irrigation in the North Dakota Tributaries area with a net reduction of 79,000 acres of nonirrigated cropland and a net increase of 79,000 acres of irrigated cropland. Energy developments over this same time period are projected to utilize 17,008 acres of land. It was estimated that of these, approximately 6,803 acres are presently cropland and 10,205 acres are presently range or pasture. The reclamation of the mined lands would decrease these figures depending on the success of this effort.

Environmental Impacts

The environmental related impacts of the recommended plan showing the net change from the existing (1975) conditions to the year 2000 for selected items are shown in table IX-12.

Streambank Protection, Knife River Indian Villages Site

The Knife River Indian Villages National Historic Site near Stanton, North Dakota, is administered by the National Park Service, this by the superintendent of Theodore Roosevelt National Memorial Park at Medora, North Dakota.

Stanton (population of 517 in 1970) is located about 50 miles northwest of Bismarck, North Dakota, near the confluence of the Knife River and the Missouri River. The Knife River Indian Villages National Historic Site is located immediately north of Stanton and covers an area of about 1,200 acres. A streambank erosion problem occurs along the Knife River adjacent to the Sakakawea site.

Table IX-10. Land Use Impacts of the Recommended Plan
Showing Net Change From Existing (1975) Conditions To The Year 2000
North Dakota Tributaries

Function/Project or Program	NET LAND USE CHANGE (ACRES)							
	Irrigated Cropland	Non-Irrigated Cropland	Irrigated Pasture	Forest and Woodland	Range or Pasture	Urban	Industrial	Other
Streambank Erosion Protection Knife River Historic Site	0	0	0	0	0	0	0	1800 lineal feet
Flood Control Hazen Project	0	1/	0	1/	1/	1/	1/	1/
Livestock Water BLM Impoundments	0	0	0	0	1/	0	0	0
Nonenergy Minerals	1/	1/	1/	1/	1/	1/	1/	1/
Scenic and Recreation Rivers (Knife, Heart, Cannonball, Yellowstone, and Missouri)	0	0	0	1/	1/	0	0	0
Agricultural Production	2/	2/	0	0	0	0	0	0
Irrigation (Private)	+79000	-79000	0	0	0	0	0	0
Energy Development								
Strip Mining	0	-5364 3/	0	0	-8046 3/	0	+13410	0
Plant and Mine Sites	0	-1439	0	0	-2159	0	+3598	0
Instream Flow (Grand, Cannonball, Little Missouri, Knife and Heart rivers)	0	0	0	0	0	0	0	1/
Preservation Unique Woodland Areas	0	0	0	+7633	-7633	0	0	0
Streambank Protection (Missouri and Yellowstone rivers)	1/	1/	1/	1/	1/	1/	1/	1/
Hydroelectric Power	0	0	0	-190	0	0	0	+190
Population	-	-	-	-	-	1/	-	-

1/ Land use changes not determined.

2/ To meet the recommended level of agricultural production would require a change of 79,000 acres of nonirrigated land to irrigated (see Chapter VII Recommended Plan)

3/ Land reclamation not taken into account.

The Knife River Indian Villages National Historic Site was authorized as part of the National Park System October 26, 1974, to preserve and interpret the irreplaceable archaeological resources of the area. The National Park Service is in the process of acquiring the needed land parcels for the site. Of primary consideration and importance are the four or five indian village sites, one of which is located along the bank of the Knife River. Due to meandering of the alluvial river, there has been considerable streambank erosion and some loss ot the archaeological resource at the river village site (Sakakawea). Therefore, the National Park Service requested the Omaha District Office of the Corps of Engineers to design some type of corrective action along that portion of the riverbank adjacent to the Sakakawea Site.

One of the principal purposes behind establishment of the Knife River Indian Villages National Historical Site is to protect the archaeological and historical resources. The national significance of the Hidatsa Villages was affirmed in 1964 when the Advisory Board on National Parks, Historic Sites, Buildings and Monuments certified the Big Hidatsa Village for designation as a viable National Historic Site. A primary objective is to preserve the irreplaceable archaeological resources and restore the natural setting of the period of historic importance; and, to stabilize and reconstruct the historic scene to best protect the area and still provide adequate public access for the desired visitor experience.

The rise and fall of the Knife River in this area is about 12 feet and the river width about 200 feet. An earth bank where the village site is situated varies in height from about 20 to 32 feet. The opposite bank varies from only about 10 to 12 feet in height, and being much lower it is actually part of the Missouri River overflow area. This low overbank area provides relief during high flows on the Knife River and reduces the flood threat at the Sakakawea Site.

Hazen Flood Control

This project is in the early planning stages with actual structural features and their costs as yet undetermined and subject to change. For these reasons, the environmental impact discussed below concerns only that portion of this element that is for flood protection for the City of Hazen. This data is also preliminary and subject to change.

The visibility of the proposed structural measures may be displeasing to some in an area of natural beauty. Quality consideration of water, land, and air resources and air pollution will be increased slightly during project construction. As concerns biological resources and selected ecosystems, no wetland areas will be altered. There will be reduced erosion and inundation on site during floods. The channel relocation or realignment will cause a temporary increase in downstream bank erosion. The labor, material and energy for construction of the project will be irretrievable.

Scenic or Recreational Rivers

Yellowstone River - North Dakota-Montana State line to Missouri River - 22 miles.

Knife River - Manning, North Dakota to Missouri River - 76 miles.

Heart River - Heart Butte Dam, North Dakota to Missouri River - 106 miles.

Cannonball River - County road South of Shields to North Dakota Bridge 1806 - 45 miles.

The above reaches are proposed as potential scenic or recreational rivers to be managed by the State of North Dakota.

Missouri River - 11 miles downstream from Garrison Dam to mouth of Heart River, Fort Lincoln State Park - 75 miles. This reach is proposed as a potential addition to the National Wild and Scenic Rivers System.

The North Dakota State Comprehensive Outdoor Recreation Plan (SCORP) has identified these segments of rivers as "some of the more extensively used canoeing streams in North Dakota."31/ The SCORP has also noted that canoeing "is one of the fastest growing activities in North Dakota."31/

Preliminary information indicates that these segments of rivers possess values that would make them eligible for addition into State and National Rivers Systems as appropriate. The rivers and their environments offer visitors recreation opportunities in fishing, hunting, camping, picnicking, sightseeing, canoeing, and other water-related activities.

These proposals include acquisition of land in fee title for both major and minor access areas and acquisition of lands in easement for the protection of the rivers and their environments. It should be noted that the Yellowstone River segment is also the route of the Lewis and Clark and Old West Trails which is considered in the Environmental Quality Plan component.

Yellowstone River - North Dakota-Montana State Line to Missouri River

Preservation of Areas of Natural Beauty	State management will preserve environment on about 4,500 acres of public and private lands.
Preservation of Free-Flowing Streams	Approximately 22 miles.
Preservation of Historic and Cultural Resources	High level of recreation is offset by protection of resources through State management. Interpretation enhances public use values. Protect historic and cultural values associated with Lewis and Clark and Old West Trails.
Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
Protection of Endangered or Threatened Vegetative Species	None known - if any are identified, they will be protected.

31/ North Dakota State Comprehensive Outdoor Recreation Plan (SCORP), 1975.

Preservation of Water Quality	State standards will be met.
Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options - limitation of development choices.
Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices constrained.

Knife River - Manning, North Dakota to Missouri River

Preservation of Areas of Natural Beauty	State management will preserve environment on about 16,800 acres of public and private lands.
Preservation of Free-Flowing Streams	Approximately 76 miles.
Preservation of Historic and Cultural Resources	High level of recreation offset by protection of resources through State management. Interpretation enhances public use values. Protect historic and cultural values associated with the river and its environment.
Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
Protection of Endangered or Threatened Vegetative Species	None known - if any are identified, they will be protected.
Preservation of Water Quality	State standards will be met.
Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options - limitation of development choices.
Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices constrained.

Heart River - Heart Butte Dam to Missouri River

Preservation of Areas of Natural Beauty	State management will preserve environment on about 23,400 acres of public and private lands.
Preservation of Free-Flowing Streams	Approximately 106 miles.

Preservation of Historic and Cultural Resources	Higher level of recreation offset by protection of resources. Interpretation enhances public use value. Protect historic and cultural values.
Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
Protection of Endangered or Threatened Vegetative Species	None known - if any are identified, they will be protected.
Preservation of Water Quality	State standards will be met.
Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options - limitation of development choices.
Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices constrained.

<u>Cannonball River</u> - County road South of Shields to North Dakota Bridge 1806

Preservation of Areas of Natural Beauty	State management will preserve environment on about 10,000 acres of public and private lands.
Preservation of Free-Flowing Streams	Approximately 45 miles.
Preservation of Historic and Cultural Resources	High level of recreation offset by protection of resources through State management. Interpretation enhances public use values. Protect historic and cultural values associated with the river and its environment.
Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
Protection of Endangered or Threatened Vegetative Species	None known - if any are identified, they will be protected.
Preservation of Water Quality	State standards will be met.
Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options - limitation of development choices.
Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices constrained.

Missouri River - 11 miles downstream from Garrison Dam to mouth of Heart River, Fort Lincoln State Park - 75 miles

Preservation of Areas of Natural Beauty	National Wild and Scenic River designation will preserve beauty on about 16,500 acres of public and private lands.
Preservation of Free-Flowing Streams	Approximately 75 miles.
Preservation of Historic and Cultural Resources	Higher level of recreation offset by protection of resources. Interpretation enhances public use value. Protect historic and cultural values associated with Fort Clark, Fort Manolan, Dougle Ditch, Slant Village, and Fort Lincoln.
Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
Protection of Endangered or Threatened Vegetative Species	None known - if any are identified, they will be protected.
Preservation of Water Quality	State standards will be met.
Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options - limitation of development choices.
Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices constrained.

Preservation of Unique Woodland Areas

This proposal is to protect and manage the unique values of 10,270 acres of ponderosa pine (pinus ponderosa), 735 acres of limber pine (pinus flexilis), and 100 acres of columnar juniper (juniperus scopulorum) and adjacent areas by administrative action on Federal lands and through acquisition of easements on private lands.

Action on the Federal lands has been taken through the unit planning process to restrict and control development that could deteriorate existing plant communities. None of the Federal land has received administrative designation, but the limber pines area is being evaluated as a Research Natural Area. Action on

the private lands consists of grazing controls under direction of local grazing associations, in conjunction with the Little Missouri National Grasslands. Management practices on the private lands are currently adequate to protect these plant communities. No immediate threat is perceived for these areas, but surface disturbances from mineral exploration or development could occur during the planning period, especially in the ponderosa pines area the proposal would provide the following:

1. The natural beauty of these woodland stands would be maintained and protected in an area generally devoid of forest vegetation.

2. Archeological, historic, and cultural sites would be protected as a result of the proposal.

3. The native diversity of the flora and fauna, valuable for human enjoyment and scientific inquiry, would be protected and managed to maintain its unique values.

4. Maintenance of woodland vegetation provides important cover for wildlife in the area. Local watershed and climate relief values would be maintained along with the conservation of soil resources.

5. These woodland areas are unique to western North Dakota, and if destroyed could not be naturally replaced. Indeed, they may be irreplaceable at any cost.

6. Activities affecting the integrity of these vegetation stands, especially the limber pines, are irreversible during the planning period, and may be irreversible regardless of the time period considered.

No adverse effects to the environment have been identified for protecting and managing this area.

Streambank Protection - Missouri River between Garrison Dam and Lake Oahe

Bank cutting is the most common form of stream erosion and is most noticeable on the outside of river bends. It is a producer of stream-transported sediment. In many cases, however, partial replacement of soil loss from stream-

bank erosion occurs through deposition on the inside curve in the same general reach. As the process grows more severe, the looping oxbows typical of an alluvial stream are formed. While balanced generally in terms of the entire river regime and while resulting in some high fish and wildlife habitat an addition to fertile flood plains, imposition's on private land ownership patterns and damages to these lands are serious problems.

Streambank erosion is a contributor of sediment which degrades the river water and results in a loss of productive land each year. The erosion is greatest on streams that have been straightened in the past and are now eroding to widen the channel, and on streams with sandy banks. Where streambank erosion is severe it causes both economic and environmental losses. Past investigations have shown that construction of conventional streambank erosion control works on a broad scale for economic return cannot be justified. Further, with all the variables involved in river mechanics, it is difficult to forecast the environmental effects.

Under Section 32 of the Streambank Erosion Control and Demonstration Act of 1974, as amended by the Water Resources Development Act of 1976, authority for work under this act has been expanded to include the Yellowstone River from intake, Montana, to its mouth. The original act authorized work on the Missouri River in the reach below Garrison Dam and in the reach between Fort Randall Dam and Sioux City. The intent of this program is to develop a demonstration of structural means for controlling bank erosion with a view toward developing the most cost effective and environmentally acceptable means. Several sites have been initially selected along the Missouri River in Nebraska, South Dakota, and North Dakota. Additional sites will be selected on both the Missouri and Yellowstone rivers as funding and scheduling permit.

The Potential Project: Installation of selective river management techniques using variations of several different types of structural

bank protection measures at 21 key locations (Streambank Erosion Control Evaluation and Demonstration Act of 1974 plus amendments).

Beneficial effect is elimination of a major source of sediment which will reduce turbidity levels.

Adverse effects are temporary turbidity of river water at construction site and disruption of vegetative cover on quarry sites to be used during construction. Conversion of some river fringe woodland to cultivated crops will reduce wildlife habitat.

Hydroelectric Power

The proposal is to construct three new units having an installed capacity of 272 megawatts at Garrison Dam. A westward extension of the existing powerhouse would utilize three modified flood control tunnels as penstock intakes. A re-regulating dam about 11 miles downstream of Garrison Dam upstream of the mouth of the Knife River would be required to control the river fluctuations due to power plant operations. The adverse environmental effects would include increased river stage fluctuations downstream from Garrison Dam and loss of about 190 acres of terrestrial habitat bordering the river due to a one-time bank slope adjustment. This loss would be mitigated by acquisition of 285 acres of similar habitat.

Energy Development

Beneficial Effects - Energy development will have no significant beneficial effects on the nonhuman environmental quality of the area.

Adverse Effects - Areas of natural beauty and human enjoyment: energy-related facilities impose definite long-term obtrusions to the visual quality of the affected areas. Such facilities include the coal mines, coal-fired generating plants, electric transmission lines, and water supply works. The anticipated number of major facilities in 1985 and 2000 is as follows:

State	Coal Mines		Electric Plants		Gasification Plants	
	1985	2000	1985	2000	1985	2000
North Dakota	9	10	9	9	0	1

Land requirements for these facility sites range from 4,554 acres in 1985 to 5,314 acres in the year 2000. In addition, strip mining activities will affect 919 acres annually in 1985 and 1,379 acres annually in 2000. Use of these lands will preclude their use for recreational and other human activities for a long period of time. Energy development has resulted in expansion of urban centers within the area and especially in those towns and cities closest to the major energy facility sites.

Increased rail and highway traffic is an annoyance in the area. Noise created by mining, transportation, and energy conversion of the coal resources is disturbing to nearby rural inhabitants and population centers.

Aerial emissions from energy production are esthetically displeasing, not only at the immediate sites of major facilities, but also for long distances downwind from sites of energy conversion plants.

Biological, geological, and ecological elements: vegetation must be cleared from sites used for major energy production facilities. Total acreage involved will amount to from 4,554 acres (1985) to 5,314 acres (2000) of natural grassland and cultivated cropland. These areas remain unvegetated for the life of the facilities. Strip mining activities destroy additional vegetative communities at the rate of about 919 acres annually in 1985 and 1,379 acres annually in 2000. Under a continuous reclamation program, the number of acres of land being reclaimed at any one time during the time frame will amount to three to five times the amount of those lands being strip mined during any 1-year period. However, the potential for fully reclaiming most of the strip mined lands to natural vegetation or to cropland is still unproven.

Natural vegetation and crops on the land surrounding, and downwind from, energy conversion plants are and will be subjected to low levels of aerial contaminants over a long period of time. Such exposure may cause acute or chronic injury to such vegetation and may also inhibit growth.

Lands used for major energy facility sites are lost as wildlife habitat for the life of the facilities. Strip mined lands are also lost as wildlife habitat until they are reclaimed. The habitat value of the reclaimed lands will be dependent on the level of success of the reclamation program. Wildlife populations most likely to be reduced by habitat losses and habitat deterioration or fragmentation include pronghorn antelope, deer, native grouse, coyotes, small grassland birds, mammals, and reptiles. Also, as long as the affected lands are in an unvegetated or sparsely vegetated condition, they will be unavailable to domestic livestock for grazing.

Depletion of water supplies and potential degradation of water quality caused by energy production will continue to have harmful effects on aquatic life in the streams and impoundments from which supplies are drawn.

Strip mining disturbs the natural topography of the landscape. Natural surface drainages as well as ground water levels and flows are altered at least temporarily. Disturbance of soils results in changes in soil permeability and exposes earth surfaces which contain high concentrations of salts, nutrients, and trace elements. Although topsoils may be removed during the mining process and saved for later replacement, the remaining soil strata may be so disturbed that the resultant soil configuration may not produce vegetation of equal quantity or quality.

Irreversible considerations: mining activities within the area already produce millions of tons of coal per year. Utilization of this resource for energy production within and outside of the study area is a permanent irreversible use of a nonrenewable resource. Water requirements for mining and for energy

conversion amount to thousands of acre-feet per year. This is an irreversible use of some water resources when considered on a yearly basis. Combined coal production and water requirements for the area are as follows:

Coal Production - North Dakota Tributaries
(million tons/year)

1985	2000
24	36

Water Requirements - North Dakota Tributaries
(acre-feet/year)

1985	2000
62,716	74,744

Significant disturbance or destruction of archeological or historic sites, especially of unidentified sites, may occur. Loss or destruction of such cultural resources is often irreversible depending on the location and nature of the site.

Water quality: the quality of both surface and ground water in the area and adjacent areas most likely suffers some degradation. Strip mining activities result in increased runoff and erosion from land surfaces, thus causing increased siltation of surface waters. Leaching of exposed earth surfaces such as spoil piles and coal stockpiles can result in increased mineralization of surface and ground waters. Potential dewatering of mine and plant excavations into natural waterways adds to the TDS concentration of receiving waters. Withdrawals of water for energy development activities, and not returning some, also tend to increase the TDS concentrations in the respective streams, water impoundments, and ground water aquifers.

Aerial emissions from energy conversion plants have a degrading effect on surface and ground waters. Salts from cooling tower drift, fly ash, sulfur, nitrogent oxides, and trace elements eventually precipitate out of the atmosphere and fall on soil or water surfaces. Contaminants which are deposited on soil surfaces may be rewetted by precipitation and then enter ground or surface waters.

The end result is increased mineral, acidic, and nutrient concentrations in these waters.

Air quality: strip mining activities such as excavating, blasting, loading, and hauling create significant levels of dust and exhaust emissions at the mining sites and along coal transportation corridors. Particulants released from potential coal refuse fires together with wind erosion of disturbed land surfaces create air pollution problems.

Stack emissions from energy conversion plants have an effect on air quality of the area. The major aerial pollutants emitted by the coal-fired generating plants and coal gasification plants are fly ash, sulfur and nitrogen oxides, and trace elements. The predicted levels of air pollutant emissions are as follows:

Emissions (Tons/Year)	North Dakota 1985	North Dakota 2000
Particulates	11,775	12,872
Sulfur Oxides	141,060	153,324
Nitrogen Oxides	117,550	279,065
Total	270,385	445,261

Effects of Strip Mining on Ground Water

Center Mine - The lignite extracted at Baukol-Noonan's mine near Center is contained in two beds stratigraphically positioned near the center of the Tongue River Member of the Fort Union Formation. The upper bed has been preserved from erosion only in the interstream upland areas. The lower (by some 30 to 50 feet), thicker bed is much more extensive, but it too has been eroded along the drainages of Square Butte Creek at the eastern periphery of the deposit and Hagel Creek at the southern periphery. Excessive depth of burial delimits the strippable range of the deposit to the north and west.

Most of the wells within the area designated by the extended mining plan draw water from depths of less than 100 feet. The shallow ground water of this

area flows, in general, from the recharge zones in the interstream uplands to the discharge zones along the valleys of Square Butte and Hagel Creeks. From the principal stripping area southwest of Center, ground water movement is toward the north and east. However, the two lignite beds are not everywhere saturated. The water seems to occur predominantly under perched conditions, resulting in a somewhat discontinuous hydrologic system. This situation is probably more prevalent in the upper bed than in the lower. At all sites investigated, the potentiometric head in the upper lignite is higher than in the lower bed, indicating a downward vertical component to the movement of water.

The average chemical composition of water drawn from 11 shallow wells in the area is as follows32/:

Dissolved solids	1,460	mg/l
Hardness (as CaCO3)	617	mg/l
Sodium	292	mg/l
Bicarbonate	517	mg/l
Sulfate	619	mg/l
Iron	1.1	mg/l

This "average water" is moderately mineralized, very hard, moderately sodic, and has a potentially troublesome iron content.

Westward expansion of Baukol-Noonan's mining operations could eventually render many of the local wells inoperable. Because the shallow ground water occurs generally under perched water-table conditions, however, the water levels in a particular well completed in one of the two coal beds probably will not decline severely until a strip pit or box cut is introduced close to the well.

Gascoyne Mine - The Knife River Coal Mining Company at its Gascoyne operation is strip mining the Harmon lignite bed of the lower Tongue River Member, Fort Union Formation. Within the existing and proposed mine area the lignite dips to the

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32/ Source: Hydrologic report in the application for Mining Permit, Center Mine, submitted by Baukol-Noonan, Inc., to the North Dakota Public Service Commission on July 20, 1976.

northeast at about 15 feet per mile and has an average thickness of 25 feet. A 5- to 40-foot bed of clay underlies the coal, and beneath this is a persistent sand and silt section about 100 feet thick.

Potentiometric data from observation wells completed in the lignite and sand units in the mine area indicate that the water in both aquifers flows in a general southerly direction under a hydraulic gradient of about 15 feet per mile. The water table in the lignite is several feet higher than the head in the sand aquifer. The lower aquifer, therefore, is recharged by downward percolating water from the lignite. These aquifers discharge to the south of the mine where both crop out.

Chemical composition of the shallow ground waters varies with the location of the sampling site in relationship to the mine site. Wells completed in the lignite and sand aquifers downgradient from the mine generally yield a more mineralized water with a much greater sulfate concentration than the wells located upgradient from the mine. Overall, the dissolved-solids concentration ranges from a few hundred to several thousand milligrams per liter, with a majority of samples in the 1,000 to 2,000 mg/l range. Most of the sampled waters are very highly sodic. Hardness generally ranges from 10 to 1,000 mg/l (as $CaCO3$). Dissolved iron levels generally are less that 1 mg/l.

Observed hydrologic effects of mining in the vicinity of the Gascoyne mine include the decline in water levels in the shallow aquifers near the box cuts. With progressive enlargement of the mined area, nearby shallow wells will be detrimentally affected, thereby requiring remedial treatment (such as deepening the well) to regain the desired supply of water.

The major geochemical consequence noted to date is a very significant increase in dissolved sulfate concentration in the lignite and sand aquifers downgradient from the mine. Continuing studies are investigating the origin of the sulfate problem and may suggest alleviatory measures.

Glenharold Mine - At the Glenharold mine, Consolidation Coal Company obtains lignite primarily from two beds. Both lie within the Tongue River Member of the Fort Union Formation, some 275 to 300 feet above its base. The lower lignite, referred to as the Stanton bed by early investigators, has recently been correlated with the Hagel bed of the Center Mine. It averages nearly 9 feet thick in the vicinity of the Glenharold Mine. Typically, 20 feet of interburden separate the Hagel bed from an overlying, apparently unnamed bed, which averages 5 feet in thickness. Mining operations are limited to the relatively narrow interval between the coal crop-line trace along the lower reaches of the fingerlike buttes bordering the Missouri River and the overburden limit line encountered a short distance upslope on the buttes.

Very few people inhabit the area within the crescent-shaped lignite deposit. There are correspondingly few wells. Most of those in existence are shallow and were probably drilled only to the first water-bearing sand horizon or lignite bed. Sparse water-level data indicate that the direction of shallow ground water flow conforms generally to the slope of the land surface.

The topographic configuration of this area precludes any substantial role of the lignite as an aquifer in the mine and adjacent vicinity. Under the premining condition, natural discharge issued from the continuous lignite exposures (or subcrop beneath glacial drift), which constituted the ground water base-level for the lignite. This natural drainage maintained low potentiometric levels for the lignite aquifer beneath the buttes. The mining process has merely shifted the line of discharge somewhat toward or into the buttes. Thus the only potentiometric effect should have been a slight lowering of water levels west of the mine reflecting the lateral displacement of the sloping potentiometric surface. Any overlying aquiferous strata are truncated with even greater frequency than the lignites by deeply incised drainages. Hydrologic effects of mining on these water-bearing units could be severe (i.e., complete drainage), but local in scope.

Indian Head Mine - At the Indian Head mine near Zap the principal lignite is the Beulah-Zap bed of the Sentinel Butte Member, Fort Union Formation. The average thickness of the Beulah-Zap bed throughout the mine area is about 9 feet. Another bed generally lies a few feet below the Beulah-Zap bed and has an average thickness of 3 feet. Both dip gently to the northwest.

The shallow aquifers of this area include the lignite beds and many irregularly distributed, lenticular sand bodies. Water-level data from observation wells completed in the Beulah-Zap bed and overlying sands show that ground water flows from the topographically highest areas within the deposit tract toward the outcrop and subcrop areas of the aquifers along the valleys of Spring Creek and the Knife River. Ground water is also discharged into the old, unreclaimed pits. Hydraulic potentials in the lignite and sand beds are very low due to the topographic positioning of the lignites and associated sands high above the river valleys (adjacent to the mine area on three sides). Natural drainage under this setting affords the aquifers very little storage capacity.

Chemical analyses of water from eight domestic and stock wells and springs in the mine vicinity give an indication of the quality of water obtainable from the lignite and overlying sand aquifers. The average dissolved-solids concentration was 1,900 mg/l. Hardness values ranged from soft to very hard. The majority of samples were hard to very hard. Seven of the eight samples were highly sodic and three contained excessive (over 1,000 mg/l) sulfate.

Westward expansion of the Indian Head Mine will, in effect, shift the zones of natural discharge toward the interstream uplands. The already low water levels in the lignite aquifers will be drawn down to the base of the lowest mined coal in the vicinity of the box cuts. It is not known how far from the box cuts this impact will extend. Water supplies equivalent in quantity could probably be obtained by completing wells in a somewhat lower Sentinel Butte or Tongue River sand or lignite aquifer. A possible impact on the water quality of the area could conceivably result from the introduction of chemically enriched (induced

by mining activities) percolating water to deeper aquifers, or, to the surface-water system at the points of ground water discharge to Spring Creek and the Knife River.

South Beulah Mine - The Knife River Coal Company, at its operation south of Beulah, is mining the Beulah-Zap bed of the Sentinel Butte Member, Fort Union Formation. Another bed, or possibly a split from the Beulah-Zap bed, is also being extracted where it lies within several feet beneath the Beulah-Zap bed. A third lignite, the Schoolhouse bed, lies 25 to 60 feet above the Beulah-Zap bed and will be exploited where it is encountered south of the present mine location. In proximity to the South Beulah mine, the three beds average 12, 4, and 8 feet in thickness, respectively.

The coal deposit of the South Beulah mine is truncated on the west by Brush Creek, on the north by the Knife River, and on the east by Otter Creek. Each of the streams flows in a deeply incised channel, which cuts the elevational plane of the lignites several miles upstream from the mine. Because these stream channels constitute, in effect, the base level for the shallow ground water system of the area, the coal beds are well-drained naturally. If the lignite beds contain water it is under very low potentiometric head. Most test holes drilled to the base of the Beulah-Zap bed in the mine vicinity encounter either a complete absence of water-bearing strata or, at best, strata containing only perched water, which discharges laterally to the nearest surface outlet.

Due to limited occurrence of shallow ground water in the South Beulah mine area, the geohydrologic impacts of surface mining should be minimal. The only potentially significant effect would seem to be the possibility of introducing to the receiver streams ground water base flow enriched in dissolved solids derived from mine-related alterations of the geochemical system.

Falkirk Mine - Falkirk Mining Company will soon begin strip mining operations at a site 3 to 4 miles southwest of Underwood. Appropriate stratigraphic designation of the commercial lignite beds to either the Tongue River Member or to the Sentinel Butte Member of the Fort Union Formation is pending the outcome of regional correlation studies. The lignite, which occurs mainly in two beds, apparently lies near the contact of the two formations. An upper bed averages 9 feet and the lower bed averages 3 feet in thickness. The interval between the two beds ranges from 10 to 20 feet. The bedrock surface is concealed by a mantle of glacial drift as much as 50 feet thick.

Geohydrologic units underlying the area include the two coal beds, lenticular silt and sand beds distributed irregularly through the stratigraphic section, and a basal sand bed in the Tongue River Member. Available data indicate that ground water within the two lignite beds and intervening strata flows radially from a potentiometric high about one mile south of Underwood. Relative to the planned mining site south of Underwood, ground water flows southward and discharges where the aquifers crop out or subcrop along the north and west flanks of Coal Lake Coulee and Weller Slough. Hydrologic data are insufficient to enable interpretation of the ground water flow characteristics in the basal Tongue River sand aquifer.

The lignite aquifers contain very hard water with dissolved-solids concentrations in the range of 350 to 1,800 mg/l.

The initial box cuts will be near the coal-crop line just north of Weller Slough. Because this is also the terminus of the shallow flow system, the impact of mining on water levels in the coal aquifers will be very localized. As mining proceeds northward, the area of hydrologic influence will expand correspondingly. In many locations, disrupted water supplies could probably be regained by drilling to the basal sands of the Tongue River. Also, mining activities could result in modifications to the quantity and quality of recharge reaching the Weller Slough glacial aquifer beneath Weller Slough.

Beulah Trench Mine - A new mine proposed by North American Coal Corporation would occupy an area north of Beulah along either side of a long, narrow valley commonly referred to as "Beulah Trench." The commercial lignite of the Beulah Trench area lies within the Sentinel Butte Member of the Fort Union Formation and is probably the Beulah-Zap bed. It is consistently 15 to 20 feet thick over most of its strippable range. The lignite outcrops all along the valley on both sides, or subcrops beneath glacial drift. Sparse test-hole data suggest that the lignite is structurally inclined somewhat toward the axis of the valley from the strippable highlands on either side of the valley.

Beulah Trench, an ancestral valley of the Missouri River, is filled with as much as 350 feet of flaciofluvial, interbedded clay, silt, sand, and gravel, which,in turn, is overlaid by alluvium composed largely of silt and clay. Test drilling has shown that certain areas within the valley are underlaid by intervals of sand and gravel of sufficient thickness and permability to transmit water yields adequate for irrigation or other large-scale uses. Whether the aquifer is extensive enough to sustain such yields has not as yet been determined. The quality of its water would allow the production of moderately salt tolerant crops. The sodium hazard is low.

Test drilling and observation-well installations have shown the lignite bed to be of dubious value as an aquifer. All test holes drilled in the strippable area east of Beulah Trench encountered only unsaturated conditions in the Beulah-Zap bed. Most of the holes drilled in the uplands west of the trench encountered saturation in the Beulah-Zap bed, but the water levels are quite low. The potentiometric gradient is toward the valley. Water levels from deeper wells in the upland areas show clearly that the vertical component of ground water movement is downward. Ground water flow in the valley aquifer diverges to the north and south from a ground water divide located about 4 miles south of the apex of Beaver Creek Bay. To the north of the divide the flow gradient is toward Lake Sakakawea and to the south it is toward the Knife River.

The direct hydrologic effects of mining on the geohydrologic environment of the upland, strippable areas will not be prominent. Disrupted water supplies formerly obtained from shallow, perched water-bearing zones may be regained by drilling to lower horizons, particularly the consistently sandy section of the lower Tongue River Member. A dominant hydrologic concern will be the possible impact on the glaciofluvial aquifer of the Beulah Trench. Interception and dissipation of a major portion of the cumulative natural discharge from the bedrock units normally received by the glaciofluvial aquifer could significantly alter the aquifer's water budget. The impact of chemically enriched leachates from the mine areas reaching the aquifer is also a concern. An active U.S. Geological Survey project is studying these and other hydrologic potentialities.

Surface Coal Mining Rehabilitation[33/]

A subject of urgent and universal concern with impending large-scale western coal development is the rehabilitation of land surfaces that have been mined or otherwise disturbed. The mining of coal, advantageous in itself, is a relatively short-term attainment. Rehabilitation, following loss of original surface productivity and depletion of the coal resource, is essential to the region and the Nation to insure the benefit of productive renewable resources.

Before commencement of any mining, an important objective of surface coal-mine planning should be a clear, written statement of rehabilitation problems and goals. Advance identification of most likely adverse effects will facilitate timely solutions as difficulties are confronted. Most mined lands and disturbed areas are sooner or later relinquished to some other form of use when the mineral is exhausted. It is important to long-term social acceptance of surface coal mining that every plan to mine also include a continuing commitment for surface

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33/ Source: Surface Coal Mining Impact and Rehabilitation Analysis, prepared by the Ad Hoc Group on Strip Mine Reclamation Analysis for Management Group, Yellowstone River Basin and Adjacent Coal Area, Level B Study, Ronald A. Pense, USBM, and Gene Schmidt, USBLM.

rehabilitation, performed as concurrently as possible. One-time treatment, or a few years care will not suffice because of unpredictable weather, sensitive interrelationships, and variations of nature.

The following reclamation timetable, based on experience, has been adopted in making these analyses: 5 years to return mined acreage to stable, productive, cultivated cropland; 10 years to return rangeland to stable, productive grazing condition; and 25 years minimum to return mined land to acceptable wildlife habitat and scenic condition.

Options - Post-mining options available in repairing surface disturbance include livestock grazing, wildlife habitat, outdoor recreation, cultivated cropland, and urban or commercial development. In selecting post-mining goals, public agencies and private owners should strive to insure uses compatible with the remaining natural surroundings and of least adverse impact on the vicinity. The natural ecosystem at the proposed mining site does not end at the lease boundary: it is part of the surrounding area, an important factor that should be taken into account during planning.

Livestock Grazing - Livestock grazing is the predominant cultural use of most potential surface mining areas in the Yellowstone Study Area. It is probable that most of the mined land is suited principally to rehabilitation for that purpose.

Post-disturbance lands best suited to grazing are those with relatively level to rolling surface contours. Slopes most acceptable to livestock do not exceed 25 percent. Optimal vegetative development requires slopes of less than 25 percent; above 33 percent, stability of the reestablished vegetation is questionable. Advantage would be realized from flatter contours, not exceeding 20 percent, permitting the use of machinery for topsoil replacement, fertilizing, and seeding. Open pit highwalls should be reduced to a slope that eliminates serious hazard to livestock.

Soil material replaced in the surface horizon must be capable of supporting vegetation that will produce forage acceptable to livestock. At the same time, the soil should provide adequate ground cover and root penetration to insure a resonable degree of erosion control. Plant species selected for revegetation must be compatible with soils, climate, season of use, and whatever native vegetation remains intact on adjacent lands.

Native plants are much to be preferred over introduced species. Natural vegetation usually requires a longer period for establishment, but its suitability to environmental conditions gives it a permanent place. The exotics may produce quicker and denser cover, but knowledge is lacking of their endurance over time--particularly their endurance to grazing pressures, their adaptability to a severely disrupted growth situation, or their propensity to spread to adjacent lands and compete there with native species.

The availability of stockwater from streams, wells, reservoirs, or other sources also should receive consideration when rehabilitation for livestock grazing is the planned objective.

Wildlife Habitat - Rehabilitating disturbed areas to meet the basic needs of wildlife is important at most locations. Wildlife use should be one of the considerations in reshaping spoil material and selecting plan species for revegetation. The best habitat for native animals is produced by modeling the rehabilitated area as closely as possible to its original image. This will prove the most attractive to those species of animals that previously inhabited the site. If new species or a greater variety of animals are desired, a greater diversity of food and plant cover must be provided.

Mined lands planned for rehabilitation with wildlife habitat as the foremost objective should be restored to a rolling contour, with slopes generally not exceeding 33 percent. Depending on cover preference of the wildlife species, it may be desirable to design localized rough and steep areas, especially near

reservoirs. A broad selection of native grasses and shrubs should be planted, with establishment of trees at suitable locations. Sagebrush revegetation will be beneficial to a wide variety of wildlife, providing soil and climatic conditions are favorable to optimum growth of the plant. Water impoundments designed specifically to the needs of wildlife should be part of the rehabilitation plan.

Outdoor Recreation - Outdoor recreation of some kind is possible in all ecosystems, and certain activities are dependent on suitable topographic features. Water impoundments are usually desirable and even necessary for certain kinds of recreation. Water features should be planned in conformance with standards approved by the appropriate authorities.

In planning for recreation as the primary use of rehabilitated land, it should be kept in mind that such use could result in increased litter and trash; in more off-road vehicle use; in increased erosion and soil compaction; and in higher water, air, and noise pollution levels depending on the type and extent of recreation planned for. If these adverse impacts prove to be entirely inconsistent with the surrounding and other land-management objectives, the recreational use should be deferred to a less intense form of use.

Cultivated Croplands - Recent writers have offered the opinion that areas of limited surface disturbance, such as borrow pits or rights-of-way, afford the best potential for rehabilitation of larger areas, such as entire surface mine pits, toward cultivated cropland. This is especially true where the predisturbance use was for cropland.

Rehabilitation should result in a flat or gently rolling surface. Slopes not exceeding 4 percent should be the object of leveling for irrigation by gravity systems. Topsoil, according to the authors of the final environmental statement on the development of coal resources in the Eastern Powder River Coal Basin of Wyoming, should be replaced to a depth of at least two feet. This should overlie an 18- to 24-inch strata of gravel, fractured rock, or other porous

material affording drainage. Fertilizing, mulching, and addition of organic matter are important. Irrigation of the rehabilitated land is far more likely to produce successful crops in the Yellowstone River Basin Study Area than is dryland agriculture. If the coal development area being rehabilitated were the kind requiring importation of large quantities of water, the aqueducts or pipelines already in place should be capable of serving the needs of extensive irrigated farming areas.

Erosion is a hazard that accompanies the farming of rehabilitated land. Therefore, suitable cropping patterns and sediment control measures should be adopted from the beginning. The danger of crop failure is considered to be higher on disturbed land than on ground in its natural state.

Urban or Commercial Development - Rehabilitation of mined land for urban or commercial development requires a surface that is level or nearly so. These are uses in which replacement of topsoil is not mandatory; even so, the practice is desirable. Where landscaping is planned it is still necessary to provide fertilizers, mulch, reseeding, and mechanical treatment on the disturbed areas. Suitable plant species may include introduced or exotic grasses, shrubs or trees. Irrigation is necessary for this type of rehabilitation.

The grasslands of North Dakota and eastern Montana afford the best opportunities in the Yellowstone Study Area for successful rehabilitation approaching original conditions. The native mid-grasses and short grasses have been replaced in practical situations with relative ease on damaged sites by either native or introduced plant species. Twelve to sixteen inches of precipitation in the grasslands provide the basis for a resilient ecology. Soil profiles are generally well developed and topsoils are abundant in nutrients and organic matter. Subsoils are usually deep and provide reserve water holding capacity. Undesirable deeper materials excavated during mining can be covered during rehabilitation of the mixed grass prairies. This favorable circumstance is

positive to the development of energy in the Yellowstone Study Area, since the largest part (about 58 percent) of known strippable coal resources underlie the grasslands.

Rehabilitation Rating System

The growing need to evaluate individual sites for their rehabilitation potential led to a system of numerical comparability ratings for the Northern Great Plains developed by Mr. Paul E. Packer of the U.S. Forest Service under its Surface Environment and Mining (SEAM) program. The Packer system of classifying lands for rehabilitation potential includes equal consideration of the elements of soil (productivity and stability), vegetation (suitability and availability), and precipitation (amount and seasonal distribution). These components are combined to produce an overall numerical rating ranging from a theoretical high of +9 to a possible low of -9 at 3-unit intervals. The scale is interpretable as follows:

+9	very good
+6	good
+3	fairly good
0	fair
-3	fairly poor
-6	poor
-9	very poor

The overall rehabilitation potential rating for the 2,342,000 acres of surface-minable land in the Yellowstone Study Area is approximately 0 or fair, with individual planning areas varying from about +4 to approximately -2. Because of the narrow limits of the resultant ratings and to provide greater contrast for lands within planning areas, the original Packer System has been extended to two decimal places. The resultant rehabilitation potential ratings for eleven North Dakota counties having surface minable coal are shown in table IX-11.

Table IX-11. Rehabilitation Response Ratings by County, North Dakota Tributaries 1/

County	Surface Minable Acres	Rehabilitation Response Rating
Adams	49,700	+4.25
Billings	22,300	+4.33
Bowman	22,300	+4.59
Dunn	22,300	+3.30
Golden Valley	37,200	+1.60
Hettinger	109,300	+5.44
McLean	19,900	+5.00
Mercer and Oliver	139,100	+3.09
Slope	114,200	+3.33
Stark	96,300	+3.75
Total Planning Area	633,100	+3.81

1/ Data not available for Grant, McKenzie, Sioux, and Morton Counties.

A summary of the environmental related impacts of the recommended plan for the period 1975 to the year 2000 is shown in table IX-12.

Social and Economic Impacts

The major social and economic impacts of the recommended plan are directly related to the development of energy in the area. Beneficial effects of this development will be a reduction of outmigration due to the approximately 1,470 new jobs created in the energy industry by 1985 and 2,055 positions by the year 2000. In addition, indirect employment of 1,790 and 2,630 will be provided by 1985 and 2000 respectively. These new jobs are expected to provide a means for reducing the outmigration of young people as well as helping in stabilizing the local economy. Many of the jobs in the energy industry are higher paying than the average income in the area and income distribution is expected to change as shown in table IX-13. The mean real family income could be expected to rise

Table IX-12. Environmental Related Impacts of the Recommended Plan Showing Net Change From Existing (1975) Conditions To The Year 2000, North Dakota Tributaries

Function/Project or Program	Environment								
				Biological Resources			Air Quality		
	Open Space and Greenbelts (Acres)	Streams (Miles)	Wilderness Primitive and Natural Areas (Acres)	Flora	Fauna	Water Quality TDS (Mgll)	NOx (1000 Tons)	SOx (1000 Tons)	Particulates (1000 Tons)
Streambank Erosion Protection Knife River Historic Site	0	0.34	-8	0	0	0	0	0	0
Flood Control Hazen Project	1/	1/	1/	1/	1/	0	0	0	0
Livestock Water BLM Impoundments	1/	0	1/	1/	1/	0	0	0	0
Nonenergy Minerals	1/	0	1/	1/	1/	0	0	0	0
Scenic and Recreation Rivers (Knife, Heart Cannonball, Yellowstone, and Missouri)	+	+324	1/	1/	1/	0	0	0	0
Agricultural Production	0	0	1/	1/	1/	1/	1/	1/	1/
Irrigation (Private)	0	1/	1/	1/	1/	1/	1/	1/	1/
Energy Development	1/	1/	1/	1/	1/	1/	+278.5	+147.2	+12.1
Instream Flow (Grand, Cannonball, Little Missouri, Knife, and Heart Rivers)	0	0	0	1/	1/	1/	0	0	0
Preservation Unique Woodland Areas	0	0	+7633	0	0	0	0	0	0
Streambank Protection (Missouri & Yellowstone Rivers)	1/	+86	1/	1/	1/	1/	0	0	0
Hydroelectric Power	0	-11	-190	0	0	0	0	0	0
Population	0	0	1/	1/	1/	1/	1/	1/	1/

1/ Undetermined

Table IX-13. Income Distribution Effects of Recommended Energy Plan
North Dakota Tributaries

Income Class	Current 1/	1985 2/	2000 2/
	Percent of Families by Income Class		
Less than 2,000	8.5	8.0	7.9
2,000 to 3,999	15.5	14.7	14.5
4,000 to 5,999	17.1	16.2	16.0
6,000 to 7,999	16.5	15.6	15.4
8,000 to 9,999	13.7	13.0	12.8
10,000 to 14,999	19.3	18.9	18.0
15,000 to 24,999	7.8	12.0	13.8
25,000 and above	1.6	1.6	1.6

1/ From "Current and Projected Population, Income and Earnings" report of Ad Hoc Work Group on Projections, Yellowstone River Basin and Adjacent Coal Area, Level B Study.

2/ Based on the following assumptions: (1) each worker represents a family; (2) salary levels are such that all coal mine workers and conversion plant workers earn from $15,000-24,999 except for rwo percent who earn over $25,000; (3) 50 percent of the construction workers earn $10,000-14,999 and 50 percent earn $15,000-24,999; (4) the indirect employment income is distributed the same as the income in the current period; and (5) all income ranges are held at 1975 real levels.

about $335 by 1985 and $685 by 2000.

Negative effects of this development include the arrival of additional people necessary for construction and operation of mines and plants which could alter existing social characteristics of the smaller communities. This is considered a negative effect based on information from public involvement during this study. In addition, publicly provided services are likely to be overextended in the short run.

While the percentage of all families in the upper income brackets would increase, many of these are likely to be immigrants. The population that would exist in the area without energy development is more likely to be receiving the lower levels of income, even with energy development. A summary of the social and economic related impacts of the recommended plan, showing the net change from 1975 to the year 2000, is shown in table IX-14.

Table IX-14. Social and Economic Related Impacts of the Recommended Plan Showing Net Change From Existing (1975) Conditions To The Year 2000 North Dakota Tributaries

Function/Project or Program	Social and Economic Impacts				
	Population	Income	Employment	Economic Stabilization (Net Benefits)	Total Annual Cost Including Capital and OM&R
Streambank Erosion Protection Knife River Historic Site	0	0	1/	0	$7538
Flood Control Hazen Project	0	0	1/	2/	2/
Livestock Water BLM Impoundments	0	2/	1/	2/	2/
Non-Energy Minerals	0	2/	1/	2/	2/
Scenic and Recreation Rivers (Knife, Heart, Cannonball, Yellowstone, and Missouri)	0	0	0	0	2/
Agricultural Production	2/	2/	2/	2/	2/
Irrigation (Private)	2/	2/	2/	2/	2/
Energy Development	+9320	$311800000	+4685	$34990000	$277310000
Instream Flow (Grand, Cannonball, Little Missouri, Knife and Heart River)	0	0	0	0	2/
Preservation Unique Woodland Areas	0	0	0	0	2/
Streambank Protection (Missouri & Yellowstone Rivers)	0	2/	1/	2/	2/
Hydroelectric Power	+5	2/	1/	2/	2/
Population 3/	+20420	2/	2/	2/	2/

1/ Provide for minor employment benefits during construction.
2/ Not determined.
3/ Total increase based on recommended plan and projected base growth.

CHAPTER X

RECOMMENDATIONS

The recommended plan for the management and conservation of the area's natural resources is presented in chapter VII.

To implement this plan and to address the many related issues and concerns discussed by the North Dakota Study Team during the course of this study, several recommendations were made by the team. To accomplish implementation of this plan, Federal, State, and local entities will have to work together with State and Federal legislative bodies and private individuals and organizations toward that end. The recommended plan and the following recommendations are intended as a flexible guide for management and conservation of the resources of the 15-county North Dakota tributaries area. They are intended to suggest courses of action which will further water resources management on a coordinated basis.

Surface and Ground Water Law

For the proper management of the State's water resources, the laws governing their use should be well defined and workable under present and near-future conditions. During the course of this study several opportunities for improvement in the North Dakota State water law were noted and the following recommendations were made by the Study Team:

RECOMMENDATION 1: The North Dakota State Legislature should:

(1) Provide legal recognition for instream flow as a valid, sustainable, water right and specifically as a beneficial use, similar to provisions in the Montana State Water Law of 1973.

(2) Enact laws protecting all aquifers from disturbances, including seismographing, that would alter the present quality of the underground water except by a joint permit from the North Dakota Water Commission and the North Dakota State Health Department.

RECOMMENDATION 2: The North Dakota State Water Commission should:

(1) Develop rules and regulations by which State and local units of government could request the Water Commission to reserve for their future use specific amounts of water for specific public purposes. These reservations would become part of the comprehensive water plan and, in addition, all water permits to be granted should conform to the plan.

(2) Sponsor public proceedings at which current methods of water allocation would be reexamined in light of contemporary and future needs. These proceedings would include:

A. Reevaluation of the Doctrine of Prior Appropriation and the Doctrine of Appurtenancy, as related to land and water speculation, exploitation, and conservation factors.

B. Discussion of alternative methods of water allocation such as legislated preferential use or administrative allocation.

C. Consideration for limited time permits and/or limited marketability or transferability of water rights.

(3) With appropriate funding, strenghthen its monitoring program for all water diverters.

Flood Damage Reduction

Flood plain management and upstream land treatment are two areas that hold potential for reduction of the area's flood damages.

RECOMMENDATION 3: The appropriate legislative and approval authority should be urged so that:

(1) The City, County, State Highway Department, and SCS will implement the existing proposal for structural protection of the town of Hazen from flood damage by Antelope Creek.

(2) The Soil Conservation Service, land management agencies, and others as appropriate, including private land owners, will review opportunities for upstream land treatment practices to reduce flood hazard throughout the area.

(3) County governments will improve flood preparedness under the umbrella of the State Civil Defense or disaster organizations; and insure adequate flood warning systems.

(4) Acceleration of the flood plain survey and flood plain delineation program administered by the State Water Commission will occur, and that this program will be expanded to include rural flood plains as well as urban areas.

Irrigation Development

The need for additional irrigation development was defined in the study. Although several potential State-regional irrigation development projects were investigated, the current trend toward private irrigation development was encouraged recognizing the limited streamflows available during certain months and resulting limits on the type of irrigation possible under private development. Water is available for water spreading type of irrigation but not for commercial irrigation. Intensive commercial irrigation development would require either storage on the west river tributaries or diversion from the Missouri River.

RECOMMENDATION 4: The North Dakota State Legislature should:

(1) Enact legislation to require a certificate of soil and water compatability before the Water Commission issues a conditional irrigation permit.

RECOMMENDATION 5: The State Water Commission is encouraged:

(1) To continue investigating the advisability of limiting the size of acreage for which irrigation water permits can be obtained.

RECOMMENDATION 6: The appropriate legislative and approval authority should be urged so that:

(1) The Soil Conservation Service, the Bureau of Reclamation, and the North Dakota State University Soils Department can accelerate the ongoing comprehensive studies of potentially irrigable land.

General Environment

The effects of development on the environment is of concern in the area. Recognizing this, and that environmental awareness necessitates additional education and research programs that address these concerns, the following recommendations are made:

RECOMMENDATION 7: The Congress and the North Dakota State Legislature should:

(1) Enact laws and provide funding for accelerated programs in acquiring and publishing environmental base data such as air and water quality, effects of interaction between man and his environment, environmentally sensitive areas and beneficial effects of various elements of the environment.

(2) Be encouraged to fund projects with high net Environmental Quality benefits, regardless of economic development benefits.

(3) Expand funding for air quality sampling network along with research for Regional Air Quality modeling.

(4) Enact legislation for stringent State and Federal reclamation and environmental laws.

(5) Enact legislation to require the appropriate agencies to develop pollution standards for all of the toxic materials emitted from coal conversion facilities, including the trace minerals.

RECOMMENDATION 8: The Congress is urged to:

(1) Enact appropriate legislation and funding for developing and publishing environmental projections under various assumptions about economic variables.

(2) Not amend the Clean Air Act of 1970 to strip Indian tribes of their right to make redesignation requests.

RECOMMENDATION 9: The North Dakota State Legislature should:

(1) Enact Statewide environmental legislation which would require preservation of natural features of major importance and assessment of public proposals having significant impact on the environment.

(2) Limit the number, height, and size of energy conversion plants in an area to meet environmental standards.

(3) Catch up on the air pollution and reclamation research drag, require a front end fee for such research from all applicants for siting, and require water use permits with any plans that would involve emissions into the air or the disturbance of the ground surface.

RECOMMENDATION 10: The appropriate legislative and approval authority should be urged so that:

(1) Landowners are encouraged to preserve existing shelterbelts through educational efforts by the Extension Service, environmental groups, SCS, and others as appropriate.

(2) Federal, State and local agencies can continue to provide technical and financial assistance to landowners in identifying and applying appropriate land and water conservation practices.

(3) Land conservation measures and upgrading of livestock water impoundments on National Resource Lands can be expedited by the Bureau of Land Management for its ongoing agency program.

(4) The North Dakota State Health Department continue its evaluation of the effects of farming practices on the air and water environment, establish limiting criteria on nutrients, pesticides, and herbicides; develop methods of on-farm retention of excessive sediment transport; and cooperate and participate in a multi-State program to control interstate pollution.

(5) Federal and State agencies that deal directly with environmental concerns are not permitted to be inactive participants in planning efforts such as this Level B Study.

(6) Energy industry and government organizations, such as agricultural experiment stations, intensify research into improved methods for rehabilitation of strip-mined lands. Industry must continue the major active role in surface rehabilitation.

(7) Further research will be conducted on the effects of atmospheric emissions from coal-fired generation facilities on agricultural crops, shelterbelts and other woodland vegetation, and native prairie. This research should include both those emissions controlled by air quality standards and emissions not currently regulated. Where such research shows substantial damage to vegetation, air quality standards should be revised to eliminate these effects.

(8) Appropriate agencies dealing in impact assessment and those preparing environmental impact studies can be required to develop systems for quantifying heretofore unquantified economic and social effects of pollution and environmental damage. Further, State environmental assessment programs should place emphasis on the quantification of environmental and social impacts and related effects rather than the socio-economic impacts.

(9) Mining of alluvial valleys should be strictly regulated.

(10) A larger percentage of the ERDA research budget goes to renewable resources such as solar, wind and conversion of excess grain to usable energy sources.

(11) Research that attempts to place a dollar value on some environmental factors should be encouraged and funding for such research needs to be expanded. The more environmental amenities that can be placed on a common scale, the easier comparisons for planning can be.

Water and Land Use Regulations

The need for several changes in land and water use regulations were recognized during the course of this study. The following recommendations are directed toward the better management of these resources:

RECOMMENDATION 11: The North Dakota State Legislature should:

(1) Enact a mined land reclamation law that would:

A. Redeem mined land reclamation bonds only after productivity comparable to that before the topsoil was disturbed has been demonstrated for three consecutive years.

B. Increase the required reclamation bonds to an amount 30 percent greater than the estimated costs of reclamation, and provide funds for adequate onsite inspection.

C. Base the issuance and renewal of later mining permits on the applicant's previous performance in land reclamation and pollution control.

D. Provide for a committee of land owners in the mining area to work with the Public Service Commission in developing the mining and reclamation plan.

(2) Enact an agricultural lands protection act that would:

A. Save a land owner from being forced out of agricultural production and into a land transition because the land becomes assessed as potential industrial or suburban land, such as the Williams Act in California, and

B. Provide for a land tenure program that could be used by those desiring to facilitate inheritance of family unit farms, such as the land tenure laws of the Province of Sasketchewan, Canada.

C. Provide compensation to the surface owner for any agricultural production foregone for all oil well sites during all the years they are not in agricultural production.

D. Protect the prime agriculture land and lands of statewide importance.

(3) Enact a surface owners protection law that would:

A. Require a surface owners consent before mining under subsurface rights.

B. Spread the tax burden to subsurface mineral owners by enacting a minimum holding tax to be paid by mineral holders.

(4) Enact an industrial development tax that would:

A. Provide front end funds for adequate community health, welfare, housing, transportation, law enforcement, recreational, and educational services for the people of areas impacted by mining through distribution of State tax funds to local governments of impacted areas.

B. Provide adequate funds for the social and economic rehabilitation of people and communities following the demise of the major mining operations.

C. Provide funds for rural and municipal water supplies of impacted areas.

(5) Enact laws denying eminent domain for the erection of transmission lines for the exporting of electric power generated in North Dakota and for the construction of coal slurry pipelines for the interstate movement of coal.

(6) Enact a resources planning law that would provide funding for open citizen participation in publicly funded resource planning programs.

RECOMMENDATION 12: The appropriate legislative and approval authority should be urged so that:

(1) Counties and city governments are encouraged where necessary to enact and enforce zoning laws and regulations to control direct use of land for mining and associated people impacts such as housing, water supplies, etc.

(2) Flood-prone areas are identified and used for flood tolerant uses while prohibiting development subject to flood damage and related public assistance.

(3) State and Federal research agencies are asked to accelerate research on cropping sequences and tillage practices with the specific aim of reducing the acreage of bare soil.

(4) State Universities and Federal and State agencies involved with agriculture are encouraged to better coordinate their recommendations on cropland management. Special consideration should be given to their management features that promote organic farming research, improved erosion control, water quality maintenance, energy conservation, and economic production.

(5) Management of State and Federal rangelands is encouraged for the maintenance and protection of native grasslands, and to discourage the conversion of these vegetation communities to other cover types.

(6) Schemes which facilitate absentee syndicate-type land purchasing are outlawed, and family farms are encouraged through incentives like tax credits and loan programs, particularly to aid small farmers or beginning farmers. A graduated land tax system would also inhibit over-size acreages.

Surface Water Quality

Water quality needs have not, in the past, been addressed to the extent of water quantity. Since in many cases water quality data is lacking, the following recommendation is made;

RECOMMENDATION 13: The appropriate legislative and approval authority should be urged to:

(1) Enact legislation to provide adequate funding to expand and maintain a comprehensive water quality monitoring network.

(2) Enact legislation to provide funding to make a comprehensive study of stream degradation and reservoir eutrophication, using Patterson Lake as one testing site.

(3) Provide the North Dakota State Health Department with appropriate legislative and approval authority to monitor and control in-stream sediment.

Outdoor Recreation

During the course of the study it became apparent that environmental data, including that for outdoor recreation, was lagging other programs; therefore, the following courses of action were recommended along with funding and authorization for implementation of a State scenic and recreation river system.

RECOMMENDATION 14: The North Dakota State Legislature should

(1) Provide funding and authorization to the State Parks and Recreation Department for implementation of a State Scenic and Recreational River System. The initial rivers designated for the system should include, but not be limited to, the Knife River (from Manning to the Missouri River), the Yellowstone River (from North Dakota/Montana border to the Missouri River), the Heart River (from Heart Butte Dam to the Missouri River), and the Cannonball River (from the county road south of Shields to North Dakota bridge 1806).

RECOMMENDATION 15: The appropriate legislative and approval authority should be urged so that:

(1) Federal, State, and private entities responsible for managing outdoor recreation areas establish a uniform method of inventorying existing recreation resources, reporting use, and identifying recreational use capabilities. This system should be kept current and made available for all resource planning purposes.

(2) A regional study can be initiated to identify nonresident demand of these resources in each of the States of the Missouri River Basin. Here it is recognized that recreation resources, including cultural, historic, and archeological resources in North Dakota and adjoining States, are utilized by recreationists considered to be nonresidents to the State or region.

(3) Various public entities find a means to prevent the clearing of woodlands so they may retain their values for recreation esthetics, wildlife, etc.

Ground Water Quality

The effects of development on ground water are a concern in the area and there is a need for additional investigation on this subject:

RECOMMENDATION 16: The North Dakota State Legislature should:

(1) Provide increased funds to establish a ground water quality and quantity surveillance and data reporting program. The Congress should provide funds to the Department of Interior to cover the public lands which it administers.

Historic Resources

In many instances historic resources are vulnerable to degradation due to excessive and unregulated public use, therefore,

RECOMMENDATION 17: the Congress should:

(1) Provide funding to the Department of the Interior and a planning grant to the North Dakota State Outdoor Recreation Agency to allow a joint survey and study of historic and archeological, and other unique areas such as caves, badlands, and other geologic or scenic areas of special significance. Once data was collected, a policy for designation, management, and protection of these sites should be established.

RECOMMENDATION 18: The North Dakota State Legislature should:

(1) Provide funding to acquire significant historic, archeological, and unique areas for preservation of the sites complementing Federal support for this general program.

Domestic, Industrial and Municipal Water Supply

In general, the municipal and domestic water supplies in Western North Dakota are highly mineralized and water quantity problems are common.

RECOMMENDATION 19: The North Dakota Study Team of the Yellowstone Level B Study, strongly supports the U.S. Bureau of Reclamation rural-municipal water study. It is suggested that the study be limited to rural domestic, municipal, light industrial and recreation uses. Full coordination between this study and the ongoing North Dakota State Water Commission study is also recommended.

Streambank Protection

Installation of selective river management techniques along the Missouri River and Yellowstone River using variations of several different types of structural bank protection measures was authorized by the Streambank Erosion Control Evaluation and Demonstration Act of 1974 plus amendments.

RECOMMENDATION 20: The Congress is urged to:

(1) Continue funding for streambank protection measures at:

A. 21 key locations along the Missouri River between Garrison Dam and Lake Oahe.

B. 24 key locations along the Yellowstone River between Intake, Montana and the mouth.

Agriculture

Dryland agriculture is the primary industry in the area. Continuation of agriculture in its present form in the area was the primary concern of the citizen participates in this study.

RECOMMENDATION 21: The North Dakota Study Team of the Yellowstone Level B Study:

(1) Recommends that farm operators diversify their operations in order to stabilize their incomes.

(2) Recommends that the U.S. Department of Agriculture urge the enactment of legislation which will return a fair profit over costs to producers of grain and livestock.

(3) Urges the granting of low interest loans by the Bank of North Dakota for the establishment of processing plants of agricultural products.

(4) Urges the North Dakota Business and Industrial Development Commission to support the development of agriculturally related recreation and liesure potential through such enterprises as: retirement and guest homes, horse and dude ranches, riding schools, raising game birds, fishing ponds, and retirement farms and communities.

(5) Urges the State Planning agencies to study the problem of urban sprawl and recommend either, or, (1) guidelines for appropriate zoning authorities, or, (2) State legislation that will provide for orderly growth.

(6) Recommends that the U.S. Department of Agriculture farm payments to farm operators be left at their present levels.

(7) Recommends that a research study be undertaken by the State universities and the ERS to: (a) identify the location and extent of conservation disinvestments; (b) the conditions under which these disinvestments are induced (e.g. price stability); and (c) specification of the types of policies and programs that will encourage and preserve public conservation investments.

(8) Recommends that NDSU research and institute additional programs that would help protect and enhance dryland agriculture.

APPENDIX

COMMENTS FROM STUDY TEAM REVIEW

The study team review process established for this report was conducted in three phases.

Phase one review - the preparation of certain sections of this report were assigned to individual State or Federal agency members of the study team. Prior to submittal of these sections to the Assistant Study Manager, they were reviewed by other study team members with expertise in the subject being discussed.

Phase two review - as the chapters of this report were prepared in preliminary draft form, they were distributed to the study team members which included State and Federal agencies, special interests, local organizations, and private individuals review and comment. The management group members also received copies for review. The following schedule was followed for this review.

Chapter	Date Sent	Date Comments Due
1-2-3	2/ 3/77	3/18/77
4-5	6/14/77	6/30/77
6-7-8	7/27/77	8/10/77
9-10	8/ 3/77	8/15/77

Phase three review - based on the overall comments received from the phase two review, a final draft of the North Dakota tributaries report was prepared. Approximately 125 copies were distributed for a 30-day review to management group members, study team members, special interests, local organizations, and private individuals.

Comments from the phase three review were received from nine Federal agencies, four State agencies, and one local organization. Comments from this local organization, two State agencies and one Federal department are attached. Enclosures including editorial and detailed comments from the other reviewers are not reproduced, but are on file at the Missouri River Basin Commission office in Omaha, Nebraska.

SWC NORTH DAKOTA STATE WATER COMMISSION

900 east boulevard
701-224-2750

bismarck 58505
north dakota

November 1, 1977

Mr. Don Ohnstad
Missouri River Basin Comm.
Suite 403
10050 Regency Circle
Omaha, Nebraska 68114

RE: SWC Project #1507

Dear Don:

This letter constitutes my authorization to delete the "Conclusions" portion of Chapter 10 in the North Dakota Tributaries volume of the Yellowstone Level "B" Study.

Based on my phone conversation with you earlier, I was of the opinion that such a section would not appear in this draft report. Moreover, we understood that the Management Team's decision to delete the conclusions from the main report automatically meant they would likewise be deleted from the North Dakota Tributaries volume. That apparently was not your interpretation.

At any rate, in view of the concern expressed by citizen participants in the study over the conclusions section, please take whatever steps as are necessary to effect their deletion.

Sincerely yours,

Vern Fahy

Vern Fahy
State Engineer

VF:GK:jd

Missouri River Basin Commission

John W. Neuberger
Chairman

John E. Acord, Montana
Vice-Chairman

Suite 403 • 10050 Regency Circle • Omaha, Nebraska 68114

"A Presidential State-Federal River Basin Commission

M E M O R A N D U M

TO: North Dakota Study Team Participants

FROM: Don Ohnstad, Principal River Basin Planner

SUBJECT: North Dakota Tributaries Report

DATE: November 16, 1977

This memo is to inform you of a major change that will be reflected in the final printing of the North Dakota Tributaries Report for the Yellowstone Level B study. This change will be removal of the conclusion section from chapter 10 of this report.

The removal of these conclusions is at the request of the State of North Dakota because of strong disagreement on the part of citizen participants with the draft conclusions presented therein.

DLO:djc

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

P. O. Box 2440, Casper, Wyoming 82602

SUBJECT: RB - USDA Comment for Yellowstone Basin and Adjacent Coal Area Level B Study - North Dakota Tributaries Report

DATE: December 14, 1977

TO:

Don Ohnstad, Principal River Basin Planner
Missouri River Basin Commission
Suite 403, 10050 Regency Circle
Omaha, Nebraska 68114

In reference to your November 16, 1977 memorandum in regard to the removal of the conclusions from the North Dakota Tributaries Report, the U. S. Department of Agriculture has the following comment.

"We object to the removing of the conclusion section from the study report. Rather than removing all the conclusions it would have been more appropriate to modify some of them. Conclusion Number 1, in particular, needed to be reworded. It is true that the study showed that North Dakota agriculture could not meet OBERS E' production; however, we cannot logically reach the rest of the conclusion based on this study. For one thing, there is nothing that says the area should meet OBERS E'.

Since the conclusions have been removed, the above discussion is moot; however, USDA wishes to go on record as preferring to change the wording of Conclusion 1 rather than dropping all conclusions.

A study that has several recommendations logically has several conclusions. If it is not possible to conclude anything, then neither should it be possible to recommend. If anything, the conclusions in the draft report were too few and not specifically related to recommendations."

Blaine O. Halliday

Blaine O. Halliday
State Conservationist
USDA Representative, Management Group

cc:
Norman Landgren, ERS, Lincoln NE
Sam Becker, FS, Missoula, MT
Allen Fisk, SCS, Bismark, N. D.

NORTH DAKOTA GEOLOGICAL SURVEY

UNIVERSITY STATION • GRAND FORKS, N. DAK. 58202 • AREA CODE 701-777-2231

EDWIN A NOBLE
State Geologist

October 28, 1977

Mr. Don Ohnstad
Principal River Basin Planner
Missouri River Basin Commission
10050 Regency Circle, Suite 403
Omaha, Nebraska 68114

Dear Mr. Ohnstad:

Thank you for sending me a copy of the final draft report on the Yellowstone Basin and Adjacent Coal Area, Level B Study, North Dakota Tributaries. My comments refer to Chapter II, Natural Resources Baseline, the portion on Physiography, General Geology, and Mineral Resources, all of which I wrote for the study, and to the discussion of Important Farmlands, which includes a series of colored maps, Figures II-14 through II-29.

Your editors have changed my text on Physiography slightly, causing some contradictions in the text as well as discrepancies between the text and figure II-1 on page II-2. The addition of the Coteau du Missouri to the list of subdivisions of the Great Plains is a change I disagree with and it causes several problems. I do not consider the Missouri Coteau (most people working in this area no longer use the term "Coteau du Missouri" as it is archaic) to be part of the Great Plains Province. Some of my reasons for including the Missouri Coteau in the Central Lowland Province are outlined in footnote 1. However, if your editors do prefer to include the Missouri Coteau in the Great Plains, then they should change the Physiographic Map, figure II-1, moving the boundary between the Great Plains and Central Lowland eastward to the Missouri Escarpment. They should also change paragraph 1 on page II-3 accordingly. The paragraph now reads exactly as I wrote it for you.

The maps (figures II-14 through II-29) are not really what they are stated to be and they are far too generalized to be useful in making decisions on allocating resources. They are quite misleading. Your reference (Patterson and others; Bull. 473, 1968) characterizes the various soil series as "very poor to unsuitable for cropland" or "unsuitable for cropland" or "good to excellent cropland" or whatever. In McKenzie County, for example, nearly all (at least 90 percent) of the areas you show as "0 to 40 percent

prime and additional farmlands of statewide importance" are characterized by Johnsgard and others as "poor to unsuitable" without a "0 to 40 percent prime..." stipulation. Please refer to plate 4 of our Report of Investigations 62 for a much more realistic portrayal of the actual soil cropland conditions in McKenzie County. Maps for the rest of the North Dakota Tributaries area counties (except McLean County), similar in approach to the McKenzie County map in RI 62, are in the possession of the Roosevelt-Custer Regional Council for Development.

It is quite misleading to indicate, as you do on page II-29, that anywhere near 0 to 40 percent of the lands shown in violet in the various counties are exceptional lands that can be farmed continuously without degrading the environment. In Billings County, for example, most of this (violet) land is badlands and certainly less than 10 percent is even mediocre cropland.

It appears to me that the definition of "prime and additional farmland" is inadequate and used much too loosely as it is applied to the North Dakota tributaries area.

Even if a more suitable characterization can be devised for the cropland-quality units shown on your maps, the usefulness of the maps will still be severely limited without a section-line grid. Even though your maps are considered to be generalized, the scale is sufficiently detailed to allow easy inclusion of section lines for those interested in locating specific areas.

Some additional random comments:

The last line of paragraph 2, page II-1 should read "...man-made reservoirs are common."
The last line on page II-4: the word Epoch is misspelled.
The word "Missouri" is misspelled in line 8, third paragraph on page II-1.

Sincerely,

John P. Bluemle

John P. Bluemle
Senior Geologist

crb
Enc.

Cartwright, ND 58838

November 12, 1977

Missouri River Basin Commission
Omaha, Nebraska

Dear Sirs,

The McKenzie County Farmers Union representing over one thousand members unanimously passed this resolution at their November 4, 1977 County Convention.

"With regard to the Yellowstone Basin Level B Study we are opposed to acquisition of any lands taken or purchased, for recreational or wilderness acres along the Yellowstone River and its tributaries in North Dakota all of which is in McKenzie County, that would in any way interfere, conflict or disrupt any present irrigation systems. We further go on record in favor of your plan for Stabilizing Missouri River Banks in the Dakotas and Nebraska and ask that you include Stabilization of the Yellowstone River Banks in North Dakota in this priority proposal."

Please give this resolution your urgent attention and let us hear from you.

Thanks,

(Signed)
McKenzie County Farmers Union
By Mrs. Frank Lassey, Co. Sec.
Cartwright, ND 58838